RECEIVED AUG - 3 1994

US Army Corps
of Engineers

Sacramento District
South Pacific Division

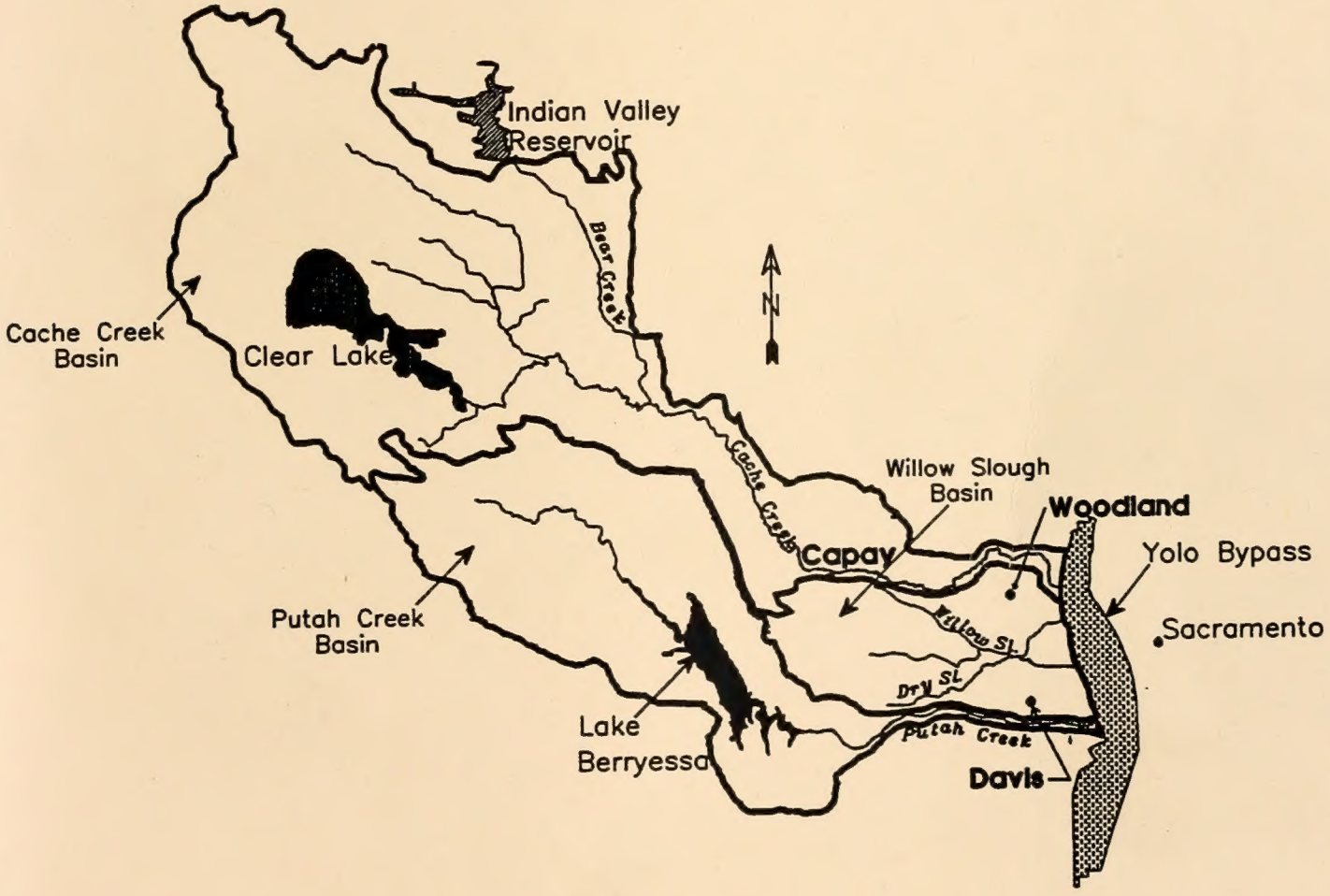
SUBJECT TO REVISION

June 1994

126

Reconnaissance Report

Westside Tributaries to Yolo Bypass, California



Cache Creek
Document
150

RECONNAISSANCE REPORT

NORTHERN CALIFORNIA STREAMS
WESTSIDE TRIBUTARIES TO YOLO BYPASS, CALIFORNIA

June 1994

U.S. Army Corps of Engineers
Sacramento District

SUMMARY

The purpose of this study was to investigate flooding and related water resources problems associated with the westside tributaries to the Yolo Bypass and determine the Federal interest in proceeding into feasibility phase studies. The study area extends from the western levees of the Yolo Bypass into the eastern foothills of the Coast Range and includes parts of Yolo, Colusa, Solano, Napa, and Lake Counties. The area includes three sub-basins of the Sacramento River Basin: Cache Creek, Willow Slough, and Putah Creek. This reconnaissance report focused on flood control improvements and environmental restoration opportunities along Cache Creek, Willow Slough, and Putah Creek.

In 1958 and 1983, Cache Creek rose to the top of both levees and overflowed its banks toward Woodland and Davis. The peak flow in 1983 at the Yolo gage was about 33,000 cubic feet per second (cfs) with an exceedence frequency of about a 20-year event. There was at least one levee break downstream from Road 102. The peak flow in 1986 was about 26,000 cfs with an exceedence frequency of about a 5-year event. Future floods of greater magnitude and duration could result in levee failure and channel overbank flooding.

Flood control measures were evaluated, including nonstructural for isolated structures and structural measures such as upstream storage, upstream detention basins, channel improvements, and levee modification/setback levees. The nonstructural measures were found to be infeasible for the Yolo County Landfill and the Davis Waste Water Treatment Plant. Technical analyses indicated that the existing flow capacity along Putah Creek is sufficient to convey the 100-year flow. As a result, no flood control measures were evaluated in this study. Two structural alternatives were found to be economically feasible on Cache Creek to reduce flood damages to Woodland and Yolo. These two structural alternatives were setback levees and channel improvement. The first costs range from $49 million to $90 million for the 100- and 200-year events. The benefit-to-cost ratios range from 1.2 to 1.8.

Environmental restoration alternatives were also investigated in this study. The restoration of existing gravel pits along Cache Creek appears feasible and warrants further study. The benefits of the restored gravel pits would include (1) increased wetland and wildlife habitat for native and migratory waterfowl, (2) recharged ground-water supplies, (3) reduced flooding, and (4) improved wildlife values along Cache Creek. Further evaluation of this restoration alternative could be pursued in the feasibility study under the authority of Section 1135 of the Water Resources Development Act of 1986.

The results of this reconnaissance study indicate that there is a Federal interest in pursuing feasibility-phase studies of flood control improvements and environmental restoration along Cache Creek. The cost of the feasibility study is estimated at about $2.2 ymillion. The City of Woodland and Yolo County have indicated their support for pursuing feasibility-level studies. Therefore, it is recommended that the feasibility-phase study of flood control improvements and environmental restoration measures be pursued for the Westside Tributaries to Yolo Bypass investigation.

RECONNAISSANCE REPORT
NORTHERN CALIFORNIA STREAMS
WESTSIDE TRIBUTARIES TO YOLO BYPASS, CALIFORNIA

TABLE OF CONTENTS

Page

CHAPTER I - INTRODUCTION 1
STUDY AUTHORITY 1
STUDY PURPOSE 1
STUDY AREA 1
STUDY PARTICIPANTS AND COORDINATION 2
PRIOR STUDIES AND REPORTS 2
Corps of Engineers 2
Federal Emergency Management Agency 3
Fish and Wildlife Service 3

CHAPTER II - STUDY AREA DESCRIPTION 5
DESCRIPTION OF BASINS 5
Cache Creek Basin 5
Willow Slough Basin 5
Putah Creek Basin 5
EXISTING AND RELATED WATER RESOURCE PROJECTS 5
Sacramento River Flood Control Project 5
Cache Creek Settling Basin 6
Indian Valley Reservoir 6
Clear Lake Dam 6
Solano Project 7
Capay Dam Modification 7
Yolo Basin Wetlands (Section 1135) 7
Yolo Basin Wetlands, Davis Site (Section 1135) 7
ENVIRONMENTAL SETTING AND NATURAL RESOURCES 7
Topography 8
Climate 8
Geology and Soils 8
Air Quality 8
Water Quality 9
Vegetation 9
Wildlife 9
Fisheries 10
Threatened and Endangered Species 10
Socioeconomic Conditions 10

Land Use 11
Gravel Mining Operations 12
Hazardous, Toxic, and Radiological Waste Sites 12
Cultural Resources 14
Recreation 15
FUTURE CONDITIONS 15

CHAPTER III - PROBLEMS AND OPPORTUNITIES 17
HISTORICAL FLOODING 17
Cache Creek 17
Willow Slough 20
Putah Creek 20
ENVIRONMENTAL RESTORATION 22
LAND SUBSIDENCE 22

CHAPTER IV - PLAN FORMULATION 25
INTRODUCTION 25
PLANNING OBJECTIVES 25
PLANNING CONSTRAINTS 25
PLANNING ASSUMPTIONS 26
Period of Analysis 26
Without-Project Condition 26
With-Project Condition 26
FLOOD CONTROL MEASURES 26
Nonstructural 27
Structural 29
ENVIRONMENTAL RESTORATION MEASURES 32
Restore Historic Riparian Habitat 32
Restore Historic Wetlands 32
TECHNICAL STUDIES 32
Hydrology 33
Surveys 33
Hydraulics and Flood Plain Delineations 33
Land Subsidence 34
Basis of Design and Cost Estimates 35
Real Estate 36
Economics 36
Environmental Resources and Cultural Resources 37
FLOOD CONTROL ALTERNATIVES 39
No Action 39
Setback Levee 39
Channel Improvement 40
COMPARISON OF ALTERNATIVE FLOOD CONTROL ALTERNATIVES . . 40
Hydraulic and Hydrologic Impacts 40

Environmental Impacts 41
ECONOMIC ANALYSIS OF ALTERNATIVES 42
ENVIRONMENTAL RESTORATION ALTERNATIVE 44
Restore Gravel Pits 44
SUMMARY 47

CHAPTER V - LOCAL SUPPORT 49
NON-FEDERAL SPONSOR 49
PUBLIC INVOLVEMENT 49

CHAPTER VI - FEASIBILITY PHASE STUDIES 51
REQUIRED STUDIES 51
STUDY MANAGEMENT 51
FINANCIAL ANALYSIS 52
Feasibility Phase 52
Construction Phase 52

CHAPTER VII - DISCUSSION AND CONCLUSIONS 53
CONCLUSIONS 55

CHAPTER VIII - RECOMMENDATION 57

TABLES

2.1 Farmland Use - Colusa, Solano, and Yolo Counties (1990) 11
2.2 Hazardous Materials Sites 14
3.1 Peak Discharges of Cache Creek at Capay Dam 20
4.1 Economic Evaluation of Nonstructural Alternatives for Willow Slough Basin . . . 28
4.2 Without-Project Average Annual Damages for Woodland and Yolo 38
4.3 First Costs of the Flood Control Alternatives 43
4.4 Total Average Annual Equivalent Damages and Benefits for Cache Creek 43
4.5 Economic Summary of the Flood Control Alternatives 44
4.6 Estimated Costs of Restoring the Gravel Pits 46
7.1 Summary of the Benefit-to-Cost Ratios 54

FIGURES

2.1 Gravel mining along Cache Creek upstream from County Road 94B 13
2.2 Gravel mining along Cache Creek upstream from County Road 94B 13
3.1 Cache Creek levee failure looking northwest over County Road 102 18
3.2 Cache Creek levee failure looking northwest in spring 1983. County Road 102 (center of photo) 18
3.3 Cache Creek levees between State Highway 113 and the Cache Creek Settling Basin 19
3.4 Cache Creek levees between State Highway 113 and the Cache Creek Settling Basin 19
3.5 Putah Creek at Road 95A (upstream) 21
4.1 Teichert Aggregate Mining Company located near Cache Creek at the junction of County Roads 96 and 20. Potential site for wetland restoration 45

PLATES

1. General and Vicinity Map
2. Study Area
3. Cache Creek Flood Plain
4. Woodland and Yolo Flood Plain
5. Willow Slough Bypass Flood Plain - 1980 FEMA Flood Map
6a. Flood Control Measures in the Study Area
6b. Flood Control Measures along Cache Creek
7. Subsidence Survey 1993 - Westside Tributaries
8. Woodland Flood Plain Profile
9. Setback Levees
10. Channel Improvements
11. Setback Levees Cache Creek 100-year Water Surface Profiles
12. Channel Improvement Cache Creek 100-year Water Surface Profile
13. Gravel Pits Wetland Restoration
14. Moore Dam Plan
15. Moore Dam Section A-A

APPENDIXES

A. Environmental Evaluation
B. Hydrology Report
C. Basis of Design
D. Real Estate Report
E. Economic Analysis
F. Pertinent Correspondence
G. Draft Feasibility Cost-Sharing Agreement
H. Initial Project Management Plan

RECONNAISSANCE REPORT
NORTHERN CALIFORNIA STREAMS
WESTSIDE TRIBUTARIES TO YOLO BYPASS, CALIFORNIA

CHAPTER I - INTRODUCTION

STUDY AUTHORITY

This study was authorized by the Flood Control Act of 1962 (Public Law 87-874). In the Energy and Water Development Appropriations Act of 1993 (Public Law 102-377), Congress directed the Corps of Engineers (Corps) to conduct a "reconnaissance study of flooding problems in the westside tributaries, Putah and Cache Creeks, of the Yolo Bypass." The study was initiated in April 1993 at the request of the Yolo County Board of Supervisors.

STUDY PURPOSE

This report is an interim response to the study authority. The purpose of this study was to investigate flood problems and develop and evaluate potential solutions to reduce these problems in developed areas along the westside tributaries to the Yolo Bypass. Results of this study were used to determine whether the study should proceed into a feasibility phase, based on a reconnaissance level appraisal of costs, benefits, and environmental impacts of the potential solutions. Also, an assessment was made as to the level of interest and support of non-Federal interests in the potential solutions.

STUDY AREA

The study area extends from the western levees of the Yolo Bypass into the eastern foothills of the Coast Range and includes parts of Yolo, Colusa, Solano, Napa, and Lake Counties (see Plate 1). The area includes three separate basins: Cache Creek, Willow Slough, and Putah Creek. The reconnaissance study focuses on flood protection and environmental restoration needs on Cache Creek between Capay and the Cache Creek settling basin, Willow Slough, and Putah Creek from Davis to the South Fork Putah Creek (see Plate 2). The primary communities in the study area include Woodland, Davis, Yolo, Madison, and Esparto.

STUDY PARTICIPANTS AND COORDINATION

The Corps, Sacramento District, conducted the study in cooperation with other Federal, State of California (State), and local agencies. These agencies included the U.S. Fish and Wildlife Service (FWS), State Department of Fish and Game, City of Davis, Yolo County, City of Woodland, and Yolo County Flood Control and Water Conservation District.

PRIOR STUDIES AND REPORTS

Numerous studies and reports provided background information and technical detail on flooding and environmental resources in the study area. These studies and reports included:

Corps of Engineers

"Cache Creek Basin, California, Final Feasibility Report and Environmental Statement for Water Resources Development, February 1979." This study investigated flood sediment deposits and related water resource problems in the Cache Creek basin. This study recommended enlarging the Clear Lake Outlet Channel, constructing a 1.1-mile-long bypass channel, and constructing a settling basin at the downstream end of Cache Creek near the Yolo Bypass.

"Cache Creek Basin, California, Cache Creek Settling Basin, General Design Memorandum, January 1987." This study was authorized by Congress in 1986 to enlarge and raise the existing perimeter levees of the settling basin for sediment storage. Construction was completed in September 1993.

"Sacramento Metropolitan Area, Final Feasibility Report, California, February 1992." This study investigated flooding problems along the Sacramento River and Yolo Bypass from the Sacramento Weir downstream to an area just south of Freeport. This study recommended levee raising around the West Sacramento area to provide for a 400-year level of flood protection, assuming that the American River 200-year flood control only dam is in place. Without the dry dam upstream, the levee would still provide at least a 150-year level of flood protection.

"Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Lower Sacramento Area, Phase IV, Draft, September 1993." This study indicated that portions of the project levees on Cache Creek, Willow Slough Bypass, and South Fork Putah Creek do not have adequate levee heights above the design water surface. The draft report indicated that this deficiency may have been caused by regional subsidence due to ground-water pumping, gas extraction, or fault movement.

"Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Mid-Valley Area, Phase III, California, January 1991." This study is the third phase of the comprehensive analysis and evaluation of about 240 miles of project levees along the Sacramento and Feather Rivers and their tributaries. This study indicated that sections of the project levees are susceptible to seepage and stability problems and recommended reconstruction of some of the levees.

"Yolo Bypass, California, Reconnaissance Report, March 1992." This study investigated flooding and related water resources problems associated with the Yolo Bypass. Results of the study indicated that there were no economically feasible alternatives to reduce flooding in the study area. However, the tributaries west of the Yolo Bypass were not investigated due to complex hydrologic and hydraulic conditions. This study recommended that a separate study be conducted to investigate the flood problems along the westside tributaries of the Yolo Bypass.

"Yolo Basin Wetlands, Sacramento River, California, Project Modification Report (Section 1135), April 1992." This study evaluated the potential of wetland restoration/modification in the Yolo Bypass and vicinity. The study recommended restoration of seasonal wetland ponds, permanent wetlands, shorebird foraging areas, riparian forests, and grasslands. The work included irrigation and drainage systems for flooding of the restored wetland areas. The areas recommended for wetland restoration are (1) Putah Creek Sinks and (2) I-80 Causeway.

"Cache Creek Basin (Lake County), California," was completed in October 1992. The purposes of this reconnaissance study were to evaluate the need for additional flood protection in the Clear Lake area of the Cache Creek basin. A variety of flood control measures were evaluated, including a detention basin, upstream storage, outlet channel improvements, modification and reoperation of the Clear Lake Dam, pumped storage, and nonstructural measures. Only nonstructural measures appeared to be economically feasible. Due to financial uncertainty, however, Lake County requested that detailed feasibility studies be temporarily deferred.

Federal Emergency Management Agency

"Yolo County, California - Unincorporated Areas, Flood Insurance Study, revised March 5, 1990." This study, which was conducted for the Federal Emergency Management Agency (FEMA), identified the flood prone areas of Yolo County.

Fish and Wildlife Service

"Fish and Wildlife Resource Management Options for Lower Putah Creek, California, Reconnaissance Planning Report, August 1993." Congress directed the FWS to prepare a planning document that identified the issues affecting fish and wildlife resources on Putah Creek and established a series of priority actions to maintain and improve those resources.

Implementation of the management measures would depend primarily on the support and cooperation of private landowners as well as numerous Federal, State, and local agencies and private groups. The final report was completed in August 1993 and released to the public.

CHAPTER II - STUDY AREA DESCRIPTION

DESCRIPTION OF BASINS

Cache Creek Basin

The Cache Creek basin is located about 15 miles northwest of Sacramento and includes Clear Lake, the largest freshwater lake in the State. The outlet of Clear Lake is the origin of Cache Creek, which flows generally southeast through the Capay Valley into the Cache Creek settling basin and then into the Yolo Bypass. The lake and creek drain about 1,150 square miles.

Willow Slough Basin

The Willow Slough basin is located about 20 miles west of Sacramento and includes Dry Creek Slough and numerous other smaller sloughs. These sloughs drain into the Yolo Bypass via the Willow Slough Bypass. The basin includes about 200 square miles.

Putah Creek Basin

The Putah Creek basin is located about 20 miles southwest of Sacramento and includes Lake Berryessa, a manmade reservoir created by the construction of Monticello Dam. Putah Creek originates above the lake and flows east through the Monticello Dam to the Yolo Bypass (via South Fork Putah Creek). Part of the flow is diverted south at the irrigation dam of Lake Solano by the Solano Water District. The basin includes about 710 square miles.

EXISTING AND RELATED WATER RESOURCE PROJECTS

Sacramento River Flood Control Project

The Sacramento River Flood Control Project was authorized by the Flood Control Act of 1917. Construction began in 1918 on this local cooperation project, sponsored by the State Reclamation Board, and most of the components were completed by 1958. The project consists of a comprehensive system of levees, overflow weirs, outlet gates, pumping plants, levee bypass floodways (including the Yolo Bypass), overbank floodway areas, enlarged and improved channels, and dredging in the lower reach of the Sacramento River. The project functions to control and divert floodwater in the Sacramento River basin and has prevented billions of dollars in damages during its history. Operation and maintenance of the project is the responsibility of the State Reclamation Board.

As part of the flood control project, levees were constructed on the downstream reaches of Cache Creek, Willow Slough Bypass, and South Fork Putah Creek. These levees were designed to control potential flooding on the tributaries. On Cache Creek, these existing levees extend on both banks from Road 102 upstream about 8 miles. On Willow Slough Bypass, these existing levees extend on both banks from the confluence with the Yolo Bypass upstream about 8 miles. On South Fork Putah Creek, these existing levees extend on both banks from the confluence with the Yolo Bypass upstream about 9 miles.

Cache Creek Settling Basin

The Corps completed initial construction of the Cache Creek settling basin in 1937 as part of the Sacramento River Flood Control Project. The settling basin, located in Yolo County about 2 miles east of Woodland, is bounded by levees on all sides and covers about 3,600 acres. The basin's basic purpose is to preserve the floodway capacity of the Yolo Bypass by trapping sediment loads carried by Cache Creek during the flood season and preventing the sediment from depositing downstream in flood control and navigation channels. Operation and maintenance of the basin is the responsibility of the State.

The sediment capacity gradually diminished after 1937. When sediments began depositing downstream, the Congress in 1986 authorized the Corps to enlarge and raise the existing perimeter levees of the basin an average of 12 feet to provide 50 years of sediment storage capacity. The upstream limit of the work was Road 102. Also, training levees were rebuilt next to the western perimeter levee to allow the entire basin to be used for sediment deposition. Construction was completed in September 1993.

Indian Valley Reservoir

The Indian Valley Reservoir is a multi-purpose project located 11 miles upstream from the mouth of North Fork Cache Creek. Completed in 1975, the reservoir was constructed by the Yolo County Flood Control and Water Conservation District. The reservoir has a storage capacity of 300,000 acre-feet, of which 40,000 acre-feet is for flood control storage, and provides irrigation water to agricultural lands in Yolo County.

Clear Lake Dam

The Yolo Water and Power Company completed the Clear Lake Dam in 1914. This reinforced concrete gravity dam is about 260 feet long and 38 feet high. The dam is located on Cache Creek about 5 miles below the lake and is currently owned and operated by the Yolo County Flood Control and Water Conservation District. Water flows from Clear Lake through the Clear Lake Outlet Channel and Clear Lake Dam to Cache Creek. The dam is operated to control the level of the lake during non-flood periods, regulate summer irrigation releases, and generate hydroelectric power.

Solano Project

The Bureau of Reclamation completed the Solano Project in 1957. The project is composed of Monticello Dam and Lake Berryessa (capacity of 1.6 million acre-feet), Solano Diversion Dam and Lake Solano (capacity of 720 acre-feet), and the Putah South Canal. The canal originates at the diversion dam and conveys water south to Solano County. Water is also released from Lake Solano to lower Putah Creek for maintenance of groundwater and riparian water rights. Three agencies control and operate the Solano Project: Bureau of Reclamation, Solano County Water Agency, and Solano Irrigation District.

Capay Dam Modification

The Yolo County Flood Control and Water Conservation District used an ultraviolet resistant rubberized material to modify the Capay Dam on Cache Creek. Modification began in October 1993 and was completed in December 1993. The new Capay Dam contains about 200 acre-feet of water during the non-flood season.

Yolo Basin Wetlands (Section 1135)

The purpose of this project is to restore historic wetlands within the Yolo Basin area and contribute to a larger interagency program to improve the quality of environmental resources in the State and nationwide. The project would modify the Yolo Bypass, a feature of the Sacramento River Flood Control Project, by restoring wetlands on two sites within the Yolo Bypass. The 3,000-acre Putah Creek Sinks Site and 480-acre Yolo Causeway Site are currently used for agriculture. The work involves constructing low berms, canals, and water control structures to restore seasonal and permanent wetlands, riparian woodland, and grassland/upland. Construction is scheduled to begin in the fall of 1994.

Yolo Basin Wetlands, Davis Site (Section 1135)

The purpose of this project is to restore historic wetlands on 400 acres of farmland northeast of Davis. This land is contiguous to the Yolo Bypass and Willow Slough Bypass, which are features of the Sacramento River Flood Control Project. The work involves restoring seasonal and permanent wetlands, riparian woodland, and grassland/upland by constructing canals, water control structures, and dikes. A Project Modification Report was completed in June 1994.

ENVIRONMENTAL SETTING AND NATURAL RESOURCES

Additional environmental information is included in Appendix A - Environmental Evaluation.

Topography

The study area is generally flat and open with little natural relief and slopes gradually upward to the west toward the coastal mountain range. Levees constructed for flood control and land reclamation in the 1800's and 1900's provide some topographic relief.

Climate

The study area has a mediterranean climate characterized by hot, dry summers and mild, rainy winters. Precipitation averages about 17 inches per year. Most of this precipitation occurs during the months of November to April. During the summer, daytime temperatures occasionally exceed 100 degrees Fahrenheit. The winter temperatures are mild and rarely drop below 20 degrees Fahrenheit.

Local meteorological conditions result from the topography of the valley. Winds are channelled by the mountain ranges that surround the valley so prevailing winds are from the southwest. Air flow passes from San Pablo Bay to Suisun Bay through the Carquinez Strait, a natural break in the coastal range, bringing cool southerly winds from the ocean in the summer and rainstorms in the winter.

Geology and Soils

The study area is geologically part of the Great Valley Geomorphic province of California. The broad valley was filled with erosion debris that originated in the surrounding mountains. Most soils in the area are recent alluvial flood plain soils. They consist of unconsolidated deposits of clay, silt, and sand and occur as flood plain deposits. Underground aquifers underlie the study area.

Air Quality

The study area lies within the Sacramento Valley Air Basin. Federal air quality standards for ozone are being exceeded several times each year. Contributors to the regional ozone problem include motor vehicle emissions and pesticide use. Major air pollution problems in the basin also include high concentrations of oxidants and suspended particulate matter. Both pollutants frequently exceed air quality standards. The largest source of oxidants is motor vehicles. The major source of suspended particulate is agriculture.

The study area is included within the jurisdiction of the Yolo-Solano Air Pollution Control District. This agency operates several monitoring stations that measure air pollution levels.

Water Quality

The water quality of the three tributaries is generally good, but the quality varies at specific sites due to the effects of geologic conditions, variable stream flows, and the quantity of local waste discharges and irrigation return flows. Higher sediment loads and extensive irrigated agriculture tend to degrade water quality.

In addition, there is local concern about the high levels of boron and salts in Cache Creek. The hot springs in the Bear Valley drainage area naturally produce these chemicals, and runoff carries them into Cache Creek. When flows decrease in the late spring, the boron and salts precipitate out on the rocks along the creek. When the fall rainy season starts, higher flows redissolve the accumulated chemical deposits, and they are carried into the Yolo Bypass and eventually the Delta.

The Yolo County Flood Control and Water Conservation District regularly monitors the concentrations of boron and salts and does not use Cache Creek water to fill their 150 miles of ditches until the water is almost free of the chemicals. High concentrations can kill English walnut trees, as well as degrade water quality downstream.

Vegetation

Natural vegetation in the study area includes riparian forest, riparian scrub/shrub, valley grassland, oak woodland, agricultural crops, and freshwater marsh. Crops grown adjacent to the streams include rice, wheat, tomatoes, and melons, grape vineyards, and orchards of fruit and nut trees. Land within the 3,600-acre settling basin is also farmed.

Riparian vegetation along Cache Creek and Putah Creek consists largely of willow, elderberry, cottonwood, blackberry, and the exotic tamarack. Downstream from Yolo on Cache Creek, levees confine the creek within defined banks where riparian vegetation has become established. Wild rose, tamarack, sandbar willow, elderberry, wild grape, and cottonwood are found on and between these levees. The south levee of South Fork Putah Creek is generally devoid of woody vegetation.

Willow Slough and Dry Slough are generally devoid of vegetation except in abandoned channels where large strands of continuous valley oaks exist. Both levees of Willow Slough Bypass have no woody vegetation. The dominant vegetation is field crops.

Wildlife

Wildlife species are associated with the type of habitat available for food, cover, and nesting. Riparian forest, valley oak woodland, and freshwater marsh are highly productive wildlife areas. Species found in these habitats include house finch, scrub jay, acorn woodpecker, egret, owl, red-tailed hawk, Swainson's hawk, virginia opossum, gray fox,

raccoon, western gray squirrel, and muskrat. During the winter months, the study area is used by migratory waterfowl and raptors.

Grassland and riparian scrub areas are used by species that feed on seeds and vegetation. Examples include the California ground squirrel, California vole, California quail, and American goldfinch. Vertebrate predators include the gopher snake, red-tailed hawk, and striped skunk.

Agricultural fields provide foraging areas for species such as Swainson's hawk, red-tailed hawk, Brewer's blackbird, and black-tailed hare. These species often nest in nearby riparian areas and feed on agricultural fields and annual grassland.

Fisheries

The number and type of fish found in the study area are influenced by the variable streamflow, shallow depths, and agricultural runoff. The predominant species found in Cache Creek are members of the minnow family such as squaw fish, carp, and roach. However, warm water sport fish such as catfish and largemouth bass are present. The fish in the Willow Slough Bypass are generally unknown but could be expected to be limited to species adapted to turbid, warm water conditions. Such species include carp, goldfish, Sacramento sucker, Sacramento squaw fish, channel catfish, and green sunfish. During wet periods, Putah Creek supports three anadromous species - Pacific lamprey, chinook salmon, and steelhead - that enter the creek via the Yolo Bypass.

Threatened and Endangered Species

A list of threatened and endangered species that may occur in the study area was requested and received from the FWS. Four Federally listed species, 18 candidate species, and one species recommended for candidate status were identified as possibly occurring in the study area. The listed endangered species are the bald eagle and the palmate-bracted bird's-beak, and the threatened species are the giant garter snake and the valley elderberry longhorn beetle. The candidate species include three mammals, three birds, one reptile, three amphibians, one fish, and eight plants.

Socioeconomic Conditions

Most of the study area is located in Yolo County, but it also extends into the southwestern portion of Colusa County and the northeastern portion of Solano County. The area is primarily rural and sparsely populated. The largest urban center is in Davis. According to the State Department of Finance (1992), Yolo County has a population of 149,200, Colusa County 17,000, and Solano County 364,700.

Agriculture is an important source of employment and tax revenue for both Yolo and Colusa Counties. In 1991, per capita personal incomes for Yolo, Colusa, and Solano Counties were $19,320, $18,803, and $17,667, respectively.

Public services in the study area are provided by the counties and their cities. Services include schools, libraries, roads, utilities, and emergency services. The major transportation routes are Interstate Highways 5, 80, and 505, and State Highways 16, 20, 45, and 113.

Land Use

Urban areas include the cities of Davis and Woodland, west of the Yolo Bypass, and Winters, north of Putah Creek. There are several unincorporated towns in the study area. These areas each include residential, commercial, and industrial development. Other developed areas include the Yolo County Landfill and the City of Davis Water Pollution Control Plant, both located north of Willow Slough Bypass, and Deganawidah Quetzacoatl University, a private Native American school located southwest of Willow Slough. The City of West Sacramento lies to the east of the study area.

Agriculture is the predominant land use in the study area. The Farmland Conversion Report prepared by the State Department of Conservation (June 1992) is maintained to provide land use conversion information to be used for future planning. There are three major mapping categories which are used: important farmland, interim farmland, and land committed to nonagricultural use. Counties in the important farmland category have modern soil survey information while counties in the interim farmland category use an interim mapping methodology until modern solid surveying equipment becomes available. Yolo and Solano Counties are categorized as Important Farmland, and Colusa County is categorized as Interim Farmland (see Table 2.1).

Table 2.1
Farmland Use - Colusa, Solano, and Yolo Counties (1990)[1]
(1,000 acres)

County	Interim or Important Farmland	Grazing Land	Urban	Other Land	Water Area	Total
Colusa	341	238	4	83	2	668
Solano	117	206	46	103	50	581
Yolo	431	136	22	56	7	652

[1] Source: California Department of Conservation, 1992.

Gravel Mining Operations

Cache Creek between Capay Bridge and Yolo provides high quality aggregate material, which has been mined since the early 1900's. The aggregate has been used primarily by Yolo and Solano Counties as construction material for roads, rail beds, and concrete structures.

During the past 20 years, there has been extensive controversy over the environmental impacts of the aggregate mining operations on land and water resources in the study area. In 1979, the Yolo County Board of Supervisors adopted interim in-channel regulations and a reclamation ordinance to control aggregate mining along Cache Creek. Yolo County is in the process of preparing a long-term resource management plan for Cache Creek. The goals of the plan include providing adequate flood-carrying capacity in the stream channel, minimizing bank erosion from stream action, encouraging riparian vegetation and wildlife habitat, and controlling aggregate mining.

Currently, there are six active aggregate mining extraction and processing operations in the study area. These operations include Syar Industries, Inc., Solano Concrete Company, Inc., Teichert Aggregates (two operations), Schwarzgruber & Sons, Inc., and Granite Construction Company. In addition, Cache Creek Aggregates has applied for a permit to mine and process gravel just downstream from Capay Bridge. The final EIS for this new operation has been certified by the County, but the permit has not been granted.

The operations vary in size, activities, and output. Most own part of their land and have agreements with landowners to mine the rest. Gravel extraction occurs both at in-channel and off-channel locations. Facilities include sand and gravel processing plants, asphalt-concrete hot mix plants, concrete batch plants, material stockpiles, settling ponds, water wells, stationary and mobile equipment, and haul roads (see Figures 2.1 and 2.2).

Hazardous, Toxic, and Radiological Waste Sites

To determine the extent of known hazardous, toxic, and radiological waste (HTRW) sites located in the study area, Federal, State, and local lists were identified and reviewed. A review of literature was conducted in order to identify HTRW sites which could require special consideration during further detailed studies.

Federal lists show no superfund sites in the study area. The nearest site on the Federal list is the Sulphur Bank Mercury Mine west of Cache Creek near Clearlake Oaks. This site involves heavy metals contamination in mining wastes. The Federal Environmental Protection Agency is currently implementing a long-term clean-up program for this site. State lists show a number of sites mainly in Davis and Woodland. Most of the listed sites involve minor tank leaks. The Yolo County HTRW file lists a number of tank leaks in the

Figure 2.1 Gravel mining operation along Cache Creek upstream from County Road 94B.

Figure 2.2 Gravel mining along Cache Creek upstream from County Road 94B.

study area, particularly around the cities of Davis and Woodland. Several hazardous materials sites would be studied further if they could be affected by feature of a proposed plan. These sites are listed in Table 2.2.

Table 2.2
Hazardous Materials Sites[1]
(Open County Files[2])

Town	Location	Substance	Notes
		Yolo County	
Esparto	Rumero Facility 26443 Woodland Ave.	Waste Oil	Open waste oil drum on vacant lot overflowed onto ground; owner ordered to clean up, agreed to do so by 1/92
Madison	Hernandez Trucking CR 89 1/4 Mi S of Hwy 16	Petroleum	Surface solid contaminated, excavated soils stockpiles & bioremediated; remediation initiated
Madison	Yolo County Housing Authority Hwy 16	Waste Oil	Removal of asphalt pad for vehicle changes showed contamination, assessment to be conducted
Rumsey	McLauglin Mine NW corner of County	Mine Wastes	Waste discharge permit for open pit gold mine operation requires monitoring for arsenic, cyanide, and mercury
Winters	Mariani Nut Company 709 Dutton Street	Chlorine	Oil reported in gutter, crystallized substance found, inconclusive of chlorine test
Yolo	CR 97B	Asbestos & Agricultural chemicals	Special investigation[3]

[1] This list excludes sites in Davis and Woodland because there are a number of different types of sites which will need to be closely evaluated if it is determined that project feature could affect these cities.
[2] Open files indicate that the hazard is currently being evaluated.
[3] Source: Department of Environmental Health Services, Yolo County, Reports Listing Hazardous Materials Files, August 1993.

Cultural Resources

Occupation of the Sacramento area began about 12,000 years ago. The study area is located in the ethnographic territory of the Patwin, who occupied a region north of Suisun Bay to above Colusa including the Cache and Putah Creek drainage. Anglo-Europeans first visited the study area in the late 1700's, but settlement did not begin until John Sutter arrived near the confluence of the American and Sacramento Rivers in 1839. After that time, western culture began to exert a strong and lasting influence on the character of the region.

Archival research was conducted at the California State Library; Bureau of Land Management - Sacramento; Sacramento District Library; and California State University, Sacramento, library. No sites in the study area are listed on or eligible for the National

Register of Historic Places. In addition, no California State Historical Landmarks are located in the study area.

A records check was requested for previous archeological survey locations and known archeological sites in the study area. Results of this records check from the Northwest Information Center, Sonoma State University, reported 17 archeological surveys for the entire study area and 14 archeological sites, one with historic aspects. However, only two surveys and two prehistoric sites, CA-Yol-135 and CA-Yol-71, are within the proposed project area. Also, the historic significance of two of the three bridges considered for replacement as part of the project would need to be evaluated.

Impacts to cultural resources are difficult to assess at this level of study because some project areas have not had intensive ground surveys. Based on available information, however, it is likely that some of the alternatives could destroy or remove existing cultural resources. Impacts could result from construction, planting, or water diversion activities.

Appropriate mitigation measures would be developed after the type and extent of any potential adverse impacts are determined. Since cultural resources are nonrenewable, avoidance and preservation are always preferable to other types of mitigation. However, any proposed mitigation measures would be formulated in consultation with the State Historic Preservation Office and the Advisory Council on Historic Preservation. Mitigation measures could include data recovery through scientific excavation, archival research, recordation, relocation, and purchase of areas with comparable cultural resources.

Recreation

According to the Yolo County Planning Department, no designated recreation areas exist along the westside tributaries. Any designated recreation areas in the study area are generally found near Davis, Woodland, and West Sacramento. The creeks, however, are used by the public for recreation. Cache Creek Canyon Regional Park, which offers picnicking, fishing, swimming, and camping is located on State Highway 16. Putah Creek Park, located 7 miles west of Winters, offers canoeing, fishing, and swimming.

FUTURE CONDITIONS

The populations of the counties in the study area are expected to grow at a higher rate than the State during the next 10 years. This growth is due to the influx of people who work in Sacramento and the Bay area. Since the counties are attempting to preserve agricultural land, future development is planned adjacent to existing urban areas. County plans include additional housing, schools, water systems, and other public facilities. This future growth will occur with or without a flood control project in place.

CHAPTER III - PROBLEMS AND OPPORTUNITIES

HISTORICAL FLOODING

Flooding in the basins is principally caused by runoff of high-intensity rainstorms during winter and spring. Storms contributing to flooding have a pattern of peaks producing large quantities of water within short periods of time. Since stream reaches are short and channel gradients steep, peak floodflows usually pass completely through the basins within a 24-hour period.

Cache Creek

Cache Creek exceeded the design channel capacity of 30,000 cubic feet per second (cfs) in 1955. In 1958 and 1983, Cache Creek rose to the top of both levees and overflowed its banks toward Woodland and Davis. According to the U.S. Geological Survey, the peak flow in 1983 at the Yolo gauge was about 33,000 cfs with an exceedence frequency of about a 20-year event. There was at least one levee break downstream from Road 102 (see Figures 3.1 and 3.2). Federal, State, and local agencies patched levee boils at that time to prevent additional levee breaks along both sides of the Cache Creek levees. The peak flow in 1986 was about 26,000 cfs with an exceedence frequency of about a 5-year event. The Yolo County Flood Control Agency monitored the levee system and patched boils to prevent levee breaks. Figures 3.3 and 3.4 show the existing Cache Creek levee conditions. Even though the storm of 1986 was the flood of record for most of the northern California area, it was not the flood of record for the westside tributaries. The flood of record was the 1983 storm event.

Hydrologic and hydraulic analyses show that Cache Creek would continue to flood Woodland and Yolo with exceedence frequencies as shown in Table 3.1. The 10-year event is assumed to be the level of flood protection that is provided to Woodland and Yolo by the existing levees along Cache Creek. The levees were originally constructed by local interests. Subsequently, the Corps modified the levees between 1938 and 1961 in order to bring them up to design standards. In 1961, the Reclamation Board accepted responsibility for the operation and maintenance of the modified levees. The present condition of the levees, despite maintenance by the State and local agencies, has reduced the level of flood protection along some reaches. Specific problems include aging, subsidence, surface erosion, internal erosion (piping), some seepage, and slides within the levee embankment or foundation soils. Also, emergency levee work was done during the 1983 and 1986 storm events.

Figure 3.1 Cache Creek levee failure looking northwest over County Road 102.

Figure 3.2 Cache Creek levee failure looking northwest in Spring 1983. County Road 102 (center of photo).

Figure 3.3 Cache Creek levees between State Highway 113 to the Cache Creek Settling Basin.

Figure 3.4 Cache Creek levees between State Highway 113 to the Cache Creek Settling Basin.

Table 3.1
Peak Discharges of Cache Creek at Capay Dam

Exceedence Frequency (years)	Peak Discharge (1,000 cfs)
500	81
100	64
50	52
20	35
10	30

The topography of the lower Cache Creek area around Woodland is very gentle rolling hills to almost flat terrain. As a result of the relatively flat terrain, the 50- , 100- , and 500-year flood events are characterized by sheet flow flooding with depths from less than 1 foot to about 3 feet. Even though the flood plains for the three events do vary slightly in areas, the flood plain boundary limits were set at flows greater than one-fourth of a foot in depth. Plates 3 and 4 show the three flood plains defined by depth of flooding. High-velocity floodflows in the Cache Creek channel would continue to erode levee banks and certain riparian areas. This erosion would result in stability problems along Cache Creek levees and channel, which could lead to increased emergency repair work and further degradation of the levees and channel.

Willow Slough

Flooding occurred in the Willow Slough basin in 1958 and 1963. No flood damages were recorded for the Willow Slough basin during the 1983 and 1986 storms. Hydrologic and hydraulic analyses indicate that there is the potential for flooding in the Willow Slough basin. Plate 5 shows the 100-year flood plain that was delineated by FEMA in 1980 for Willow Slough and nearby sloughs.

Since there is little urban development in the basin, structural measures for flood protection were not considered to be economically feasible. Nonstructural measures were evaluated to reduce flood damages to some structures. Residents in Yolo County, as well as local agencies and organizations, have indicated an interest in nonstructural and environmental restoration measures.

Putah Creek

Prior to the construction of the Monticello Dam and Lake Berryessa, some flooding occurred in 1955 along Putah Creek. Current reconnaissance-level hydrologic and hydraulic

analyses show that with the construction of Monticello Dam and Putah Creek Diversion Dam, Putah Creek is able to contain the 100-year flow. Therefore, no flood plains were developed for Putah Creek. However, the hydraulic analysis was based on very limited surveying data for the existing channel cross sections. In 1986, flooding occurred on Putah Creek at the mouth of the Yolo Bypass, but the flows did not affect any urban areas (see Figure 3.5).

Figure 3.5 Putah Creek at Road 95A (upstream).

ENVIRONMENTAL RESTORATION

Federal, State, and local flood control and water development projects account for major losses of aquatic, wetland, and riparian habitats in the Central Valley. Direct and indirect impacts from these projects have contributed to a serious decline in the biological resources in the Yolo Basin, including the westside tributaries.

Corps projects along the rivers and streams have caused direct impacts on riparian and wetland wildlife habitat areas through construction of levees and bypasses, regulation of floodflow releases from dams, and removal of sediment and vegetation. These activities have destroyed streamside vegetation and denied floodwater to wetlands and riparian areas. Fish and wildlife continue to be adversely affected as these habitat areas diminish or deteriorate.

Indirect impacts on riparian and wetland wildlife habitat areas have resulted from upstream water-related projects, which have changed the hydrology and flood plains of the westside tributaries. Reduced peak flows have allowed and/or encouraged the conversion of historic riparian and wetland habitats to urban and agricultural areas. This conversion has largely eliminated previously abundant fish and wildlife habitat values. Thus, fish and wildlife resources have significantly diminished.

Native fish, especially anadromous species, have also been directly affected by water-related projects. Upstream impoundments have altered the hydrology of the westside tributaries and eliminated spawning areas, while channel clearing and levee construction have reduced fisheries and shaded riverine habitat along the tributaries.

One potential restoration opportunity is the gravel mining area along Cache Creek. This area now has low to moderate wildlife value due to deep, trapezoidal channels, lack of topographic variation and natural channel, near absence of riparian vegetation, and low habitat diversity. Restoring historic wetland habitat in abandoned gravel pits would benefit the entire creek.

This restoration work could include minor regrading, planting with native species, and using existing irrigation canals to route winter and spring flows into the pits. The water could support a diverse mixture of seasonal and permanent wetlands, riparian woodlands, and associated upland habitat while also recharging groundwater aquifers.

LAND SUBSIDENCE

Recent studies of subsidence in the Sacramento Valley by the U.S. Geological Survey and other agencies indicate that excess groundwater pumping is responsible for regional land subsidence in the study area. Phases III and IV of the Sacramento River System Evaluation determined that project levee height deficiencies along Cache Creek, Willow Slough, and

Putah Creek may be due to regional land subsidence. Because the subsidence did not result from project designs deficiencies, however, no corrective action was proposed as part of the Sacramento River System Evaluation work. Phase IV recommended that the Reclamation Board, the non-Federal sponsor for the flood control project, evaluate the levees and take any corrective action necessary to restore the height deficiencies. This work would be performed as part of operation and maintenance activities.

Yolo County is concerned about the extent of subsidence in the region and has requested that the State and Federal agencies investigate the subsidence problem. The State is currently studying conjunctive water use in the region, and subsidence is one component of their study.

CHAPTER IV - PLAN FORMULATION

INTRODUCTION

The primary purpose of the reconnaissance level study was to determine if there is a Federal interest in at least one flood control alternative that would reduce the flood damages in the study area. Plan formulation consisted of (1) identifying objectives, constraints, and assumptions used to develop and evaluate alternatives, (2) identifying flood control and environmental restoration measures to help reduce flood problems and restore fish and wildlife resources, (3) formulating measures into alternatives, and (4) evaluating the technical, environmental, and economic feasibility of those alternatives.

PLANNING OBJECTIVES

The overall planning objectives were to reduce flood damages and restore fish and wildlife resources in the study area. The study focused on Cache Creek since the major flood threat to developed areas in Woodland and Yolo was from Cache Creek. However, flooding problems and environmental restoration opportunities were considered along Willow Slough and Putah Creek, but not in detail. Specific objectives of this study were:

- To reduce flood damages in Woodland and Yolo from insufficient channel capacities on Cache Creek.
- To reduce flood damages to development along Willow Slough.
- To reduce flood damages to development along Putah Creek.
- To restore fish and wildlife habitats within the study area.

PLANNING CONSTRAINTS

Specific constraints were:

- To avoid induced flooding and increased sedimentation in areas downstream from the proposed alternatives.
- To minimize adverse impacts to existing vegetation and wildlife.

PLANNING ASSUMPTIONS

Formulation and evaluation of flood damage reduction measures and alternatives were based on the most likely conditions expected to exist in the future with and without a project.

Period of Analysis

The period of analysis for this study was considered to be 100 years, from 2000 to 2100. Construction of a project could potentially begin in 1998 and be completed by 2000, the base year. However, the actual base year would depend on congressional authorization, funding, and various other factors.

Without-Project Condition

The without-project condition is the condition expected to occur if no project is constructed. Under the without-project condition, no action would be taken by the Federal government to participate in flood control solutions along Cache Creek, Willow Slough, and Putah Creek. The without-project condition assumed that the work proposed in Phases III, IV, and V of the Sacramento River Flood Control System Evaluation would not be in place since this work has not been approved. Phase III and IV of the report indicated that the levee height deficiency may have been caused by regional land subsidence due to ground-water pumping, gas extraction, or fault movement.

As mentioned in Chapter II under the "Sacramento River Flood Control Project," existing project levees were constructed on the downstream reaches of Cache Creek, Willow Slough Bypass, and South Fork Putah Creek. These levees were designed for approximately 10-year level of flood protection on the three tributaries. The levee reaches are about 8 to 9 miles in length. The existing levee heights range from 5 to 15 feet above the ground surface elevation, and crown widths are about 12 feet. The levees have been operated and maintained by the State Reclamation Board and local agencies since 1961.

With-Project Condition

The with-project condition involves the implementation of one or more flood control alternatives. Each alternative would provide an increased level of flood protection. The emphasis would be to provide a high level of flood protection that is economically and environmentally feasible.

FLOOD CONTROL MEASURES

Various nonstructural and structural measures were identified by the Corps and local interests during the study with the objective of providing increased flood protection to developed areas. These measures included nonstructural, upstream storage, upstream

detention storage, levee modification/new levees, channel improvements, and combination of measures. The locations of these measures are shown on Plates 6a and 6b.

Nonstructural

The purpose of nonstructural measures was to reduce the threat to public health and safety and flood damages at the point of damage rather than to control the floodwater. Nonstructural measures would reduce flood damages without significantly altering the nature or extent of flooding. The measures considered in the study area included flood warning and evacuation, temporary closures, ring levees and floodwalls, raising existing structures, and structural relocations. However, since Yolo County has already implemented formal flood warning and evacuation plans, this measure was not considered further. In addition, raising existing structures was not considered further due to high costs and possible damage to the structural stability of the structures.

Cache Creek - Nonstructural measures to reduce flood damages in Woodland and Yolo would not be economically feasible or effective during large flood events such as a 100-year flood. Temporary closures would not effectively protect residential structures in the two communities. A major problem with ring levees and floodwalls around Woodland and Yolo would be rerouting roads, bridges, railroads, and other means of transportation in and out of the area. Ring levees and floodwalls would also limit future growth in the area, and it would not be economically feasible to enclose the City of Woodland. Also, relocating Woodland and Yolo would be cost prohibitive. For these reasons, nonstructural alternatives for Cache Creek were not considered further.

Willow Slough Bypass - Nonstructural measures to reduce flood damages were considered for the Yolo County landfill (YCL) and Davis Waste Water Treatment facility (DWWT). The estimated maximum flood damages of the 100-year event for the YCL and DWWT were $6.6 million and $4.5 million, respectively.

Two nonstructural measures were considered for the YCL. The first measure involved constructing new levees around the west, north, and east sides of the landfill and raising the existing Willow Slough Bypass levees along the south side of the landfill. About 5,000 linear feet (LF) of new 8-foot-high levee would be required along the west side of the YCL. About 2,700 LF of new levee would be required on the north side of the YCL. This new levee would vary from 8 to 11 feet high. Also, 5,000 LF of new 11-foot-high levee would be required along the east side of the YCL. The 2,700 LF of existing Willow Slough Bypass levee on the south side of the YCL would be raised about 3 feet.

The second measure for the YCL involved constructing floodwalls instead of levees. The locations, heights, and lengths of the floodwalls would be the same as the new levees in the first measure.

Two measures were also developed for the DWWT. The first measure involved (1) constructing 640 LF of 6-foot-high levee along the east side of the DWWT, (2) raising 1,020 LF of existing levees about 5 feet along the north and west sides of the DWWT, (3) constructing 130 LF of 5-foot-high levee along the southwest side of the DWWT, and (4) raising 680 LF of existing levees on the Willow Slough Bypass about 2 feet along the south side of the DWWT.

The second measure involved constructing new floodwalls instead of levees. The locations, heights, and lengths of the floodwalls would be the same as the levees in the first measure.

Table 4.1 shows the benefits and costs for these nonstructural measures. The various measures for the YCL and DWWT were designed to provide 100-year level of flood protection. Based on the benefits and costs, the benefit-to-cost ratios for the ring levee measures for the YCL and DWWT were about 0.5 and 0.9, respectively. The benefit-to-cost ratios for the floodwall measure were about 0.4 and 0.6. Since none of these alternatives were economically feasible, nonstructural measures for these two facilities were not considered further. In addition, structural measures were not considered further due to high construction costs and limited urban development.

Table 4.1
Economic Evaluation of Nonstructural Plans for Willow Slough Basin

Measures	First Costs[1] ($1,000)	Annual Costs ($1,000)	Ave Annual Benefit ($1,000)	BCR[2]
Yolo County Landfill				
Ring Levee	1,470	120	57	0.5
Floodwall	1,860	150	57	0.4
Davis Water Pollution Control Plant				
Ring Levee	380	30	28	0.9
Floodwall	620	50	28	0.6

[1] Costs include real estate, environmental mitigation, cultural resources, utilities, engineering design, and construction management.
[2] Benefit-to-cost ratio.

The benefit-to-cost ratios for these two facilities were based on estimated damages provided to the Corps by the Yolo County Department of Public Works and the Davis Public

Works Department. The 100-year event was used as the basis for calculating the overall average annual damages and benefits. The annual benefits for the two facilities were calculated based on a 10-year existing level of flood protection. The first and annual costs were based on 1993 price levels, 8 percent interest rate, and a 100-year project life.

Even though the benefit-to-cost ratios for the YCL and DWWT did not justify a Federal interest in flood control, further studies of the hydrology and hydraulic conditions in the Willow Slough basin may be warranted. The preliminary technical evaluation was based on limited existing data and did not fully analyze the flooding potential in the basin. Further evaluation of the benefit-to-cost ratios would require detailed analyses of the (1) survey and topographic data for the Willow Slough basin, (2) Willow Slough flood plain, (3) hydrology, (4) hydraulic design, (5) design and costs estimates, (6) total flood damage estimates, (7) environmental impacts and mitigation, and (8) real estate costs.

Putah Creek - Hydrologic and hydraulic analyses indicate that the existing flow capacity on Putah Creek is sufficient to convey the 100-year flow. As a result, no nonstructural flood control measures were evaluated in this study.

Structural

Upstream Storage on Cache Creek - This measure would reduce peak floodflows by permanently storing excess flows upstream and then controlling downstream releases. The dam and reservoir would be single purpose for flood control or multipurpose for flood control, water supply, hydropower, and recreation.

In 1988, the Corps evaluated the economic feasibility of several combinations of storage space and downstream objective releases. The objective was to provide at least 100-year level of flood protection downstream along Cache Creek. The only alternative that was economically feasible was a dam and reservoir at the Blue Ridge site on Cache Creek just upstream of Rumsey. The project design was a roller-compacted concrete dam with a 300-foot-wide overflow type spillway. The proposed reservoir had a surface area of 7,000 acres and a storage capacity of 945,000 acre-feet. The reservoir would provide storage space for water supply, sediment, and flood control. At that time, the average annual flood control benefits were estimated to be $818,600, and the average annual flood control costs were $725,400. The resulting benefit-to-cost ratio was 1.1.

Further studies were discontinued in 1988 due to the lack of a non-Federal sponsor. At the present time, there appears to be no local support for a multipurpose dam and reservoir at the Blue Ridge site so this measure was not considered further.

Upstream Detention Storage on Cache Creek - Flood detention storage differs from reservoir storage in that there is no permanent pool for water conservation. The purpose of a detention basin is to temporarily store excess floodwater to limit downstream flows to the existing channel capacity. The detention basin would normally be dry and would impound

water only during flood events. The detention basin would reduce the peak flow of flash floodwater and reduce the potential for flood damages.

Three potential detention basin sites in the Cache Creek basin were evaluated to determine their effectiveness in reducing floodflows along Cache Creek. The three sites were Bear Creek, Wilson Valley, and Cache Creek downstream from Capay Dam (see Plate 6a).

The Bear Creek site is located about 11 miles upstream from its confluence with Cache Creek. This on-stream site was identified by the State Department of Water Resources in the early 1970's as part of the State's Eel River project. Current hydrologic analysis indicates that even when 100 percent of the runoff is stored at the Bear Creek site, downstream flows in Cache Creek would only be reduced by about 9 percent of the total Cache Creek inflow. For example, the peak discharge for the 100-year flood event at Yolo decreases from 62,300 cfs to 56,800 cfs (8.8 percent reduction) at a maximum storage volume of 26,000 acre-feet at the Bear Creek site. Based on these results, a significant reduction in floodflows is not possible. Therefore, the Bear Creek site was not considered further.

The Wilson Valley site is located on Cache Creek about 5 miles downstream from the confluence with the North Fork Cache Creek. In the early 1970's, the State Department of Water Resources conducted a foundation analysis of the on-stream site as part of the Eel River project. The analysis indicated that weak foundation conditions limited the storage capacity of the Wilson Valley site to 37,000 acre-feet and this volume would be filled with sediment in 80 to 90 years. Current hydrologic analysis indicates that the peak discharge for the 100-year flood event at Yolo would be decreased from 62,300 cfs to 46,700 cfs (25 percent reduction) with a maximum storage volume of 37,000 acre-feet in the storage basin. In addition, the reduced peak discharge for the 50-year event with the 37,000 acre-foot basin is well above the estimated nondamaging capacity. As a result, significant reductions in flood damages would not be achieved with the storage available at the Wilson Valley site. Therefore, the Wilson Valley site was not considered further.

The Capay site is located downstream from Capay Dam on Cache Creek. The project would involve constructing off-stream detention ponds adjacent to Cache Creek. Current hydrologic analysis indicates that 75,000 acre-feet of detention capacity is required in order to decrease the peak discharge of the 100-year event at Yolo from 62,300 cfs to 25,000 cfs (nondamaging capacity). Assuming a depth of storage of 20 feet, the required detention area is estimated to be 5.9 square miles. Due to this large land requirement, as well as construction and operational difficulties, the Capay site was not considered further.

In summary, construction of upstream detention storage on Cache Creek was not considered further.

Levee Modification/New Levees on Cache Creek - Levee modification and constructing new levees would protect areas on the landside of the levees from flood inundation and provide more effective conveyance of floodwater through the project area. Levees would be constructed along the stream bank to contain floodflows or set back from the banks to reduce construction impacts to riparian vegetation and wildlife. Levee raising and new levee construction would be required along both banks of Cache Creek from Road 102 to Road 94B in order to provide at least 100-year level of flood protection to Woodland and Yolo (see Plate 6b). Levee modification involves 1V:3H waterside slopes and 1V:2H landside slopes, as recommended by Phase III of the Sacramento River Flood Control System Evaluation. Some reaches of the levees on Cache Creek have less than the design crown width and height, and levee embankment slopes are flatter than the design specification. In some cases, the differences are significant and suggest levee embankment subsidence and slumping at the base of the levee.

Levee raising on some reaches of Cache Creek would cause channel flow velocities to increase. In order to stabilize the channel bottom and levee side slopes and reduce flow velocities, setback levees and slope protection measures would be constructed as required. In some cases, the levee reaches would require slope protection to stabilize the slope from slumping or erosion. Also, some roads, bridges, and pipeline utilities would have to be relocated. Raising levees and constructing setback levees would have some adverse impacts on existing riparian habitat. However, appropriate mitigation measures would be implemented to offset any adverse impacts. This measure was considered further.

Channel Improvements on Cache Creek - Channel Improvements consist of clearing and enlarging the existing channel in order to convey excess floodwater within the channel area.

Channel improvements would involve enlarging Cache Creek from Road 94B to Road 102, rebuilding bridges and railroad crossings to accommodate the increased channel width and depth, removing riparian vegetation, and removing other obstructions and sediment (see Plate 6b). In order to contain the floodflow without causing additional erosion or slumping of the channel banks, slope protection would be needed. This measure was considered further.

Combination of Measures on Cache Creek - Structural measures can be combined to provide effective flood control to developed areas. Possible combinations of measures would include an upstream detention basin to contain portions of the floodwater along with downstream channel improvements and levee modifications/setback levees. The advantage of incorporating the detention basin would be less channel and levee work. However, the cost of a detention basin alone is very high and would only provide a minor reduction in total flood volume of about 9 percent. Also, there would be adverse environmental impacts associated with the detention basin measure. Containing the 100-year floodflow within the Cache Creek floodway would still require a significant level of channel improvement and

levee modification. The combined costs would be cost prohibitive. As a result, this measure was not considered further.

ENVIRONMENTAL RESTORATION MEASURES

The purpose of environmental restoration is to restore the environment in areas degraded by previous development projects. This section identifies possible measures to accomplish this purpose. In addition, flood control measures could be specifically designed to restore environmental resources and reduce potential flood damages in the study area. Riparian habitat, wetlands, waterfowl, and anadromous fish are considered to be the most significant environmental resources.

Restore Historic Riparian Habitat

The Corps, FWS, State Department of Fish and Game, Yolo County Resource Conservation District, and several local non-governmental organizations have recognized the importance of restoring riparian habitat in the Yolo Basin. In the study area, restoration could be achieved by regrading terraces, excavating channels, excavating low-flow channels, and/or replanting terraces and flood plains.

Restore Historic Wetlands

Restoration of wetlands in the Yolo Basin would contribute to international, regional, and local efforts to protect wetlands habitat. The goal of the North American Waterfowl Management Plan (NAWMP) is to restore and maintain the diversity, abundance, and distribution of waterfowl that occurred from 1970 through 1979. The Central Valley of California is one of the seven high priority areas identified by the NAWMP for protection, restoration, and enhancement. The California Central Valley Habitat Joint Venture has identified the Yolo Basin as a first priority area and has a goal of 10,000 acres of restored wetlands. The Yolo Basin's strategic location within the Pacific Flyway, the migratory route for millions of birds traveling from nesting sites in Canada to wintering grounds in Mexico, makes it a vital international resource.

TECHNICAL STUDIES

Technical studies were conducted to support development of alternatives from the various measures. These technical studies evaluated flooding problems and environmental restoration opportunities, and results were used to develop potential alternatives. This section includes brief discussions of these technical studies. The focus was on Cache Creek based on historical flooding problems, urban development, existing channel capacity, and potential flood damages.

Hydrology

The existing hydrologic data for Cache Creek, Willow Slough, and Putah Creek were reviewed and updated. The hydrologic analysis is included in Appendix B - Hydrology Report.

Computer program HEC-1 was used for the Cache Creek basin model. Discharge hydrographs were developed for the without-project condition for Cache Creek for the 50-, 100-, 200-, and 500-year flood events. Existing hydrologic information was updated for Willow Slough. Historical flood stages and cross sections were used to verify the channel capacity of Putah Creek. It was determined that Putah Creek could contain the 100-year flow within the existing levee system.

Surveys

Existing topographic mapping, field cross sections, and reconnaissance-level survey data were collected along reaches of the Cache Creek channel. The cross sections were spaced about 200 feet apart near Capay Dam and 2,000 feet apart downstream from the dam. Cross sections were taken at Capay Dam, Capay Bridge (Road 86), 1.5 miles upstream of Interstate Highway 5, and 0.6 mile downstream from Road 102. In October and November 1989, the State Department of Water Resources surveyed the levee crowns as part of the system evaluation work.

Hydraulics and Flood Plain Delineations

Hydraulic modelling and flood plain delineations were conducted on Cache Creek from Capay to the Cache Creek settling basin. Water-surface profiles were developed for existing (preproject) and with-project design conditions for Cache Creek using computer program HEC-2.

Manning's "n" values varied from 0.03 to 0.07 for overbank, channel, overland to urban, and rural conditions. Contraction and expansion loss coefficients ranged from 0.1 to 0.3 for gradual transitions to 0.3 to 0.5 for bridge crossing sections.

Uncertainty allowance is the vertical distance from the nominal design water surface to the top of the excavated channel, levee, or low chord (lowest point) of a bridge or culvert. The uncertainty allowance was 1 foot under bridges. The uncertainty allowance for the levees ranged from less than 1 foot to about 3.5 feet.

Flow velocities for the mostly linear channel reaches were maintained between 5 and 10 feet per second, with the average velocity at 7 feet per second (EM 1110-02-1601). For non-linear channel reaches, where the flow velocity exceeded 10 feet per second, slope protection (riprap) was included to minimize erosion.

The hydraulic analysis incorporated the estimated existing levee failure locations, including the Probable Non-failure Point (PNP) and Probable Failure Point (PFP) for the existing Cache Creek levee system. The PNP is defined as the highest vertical elevation on the existing levee where it is determined to be highly unlikely that the levee would fail if the water-surface elevation is at or below this level. The PNP for reaches along Cache Creek ranged from 1 to 3.5 feet below the top of the existing levees. The PFP is defined as the lowest vertical elevation on the levee where it is determined to be highly likely that the levee would fail. The PFP for reaches along Cache Creek ranged from the point above the PNP to the top of the existing levee. The maximum PFP was assumed to be the top of the levees. These elevations were based on field inspections, elevations of existing levee embankment sections, and historical performance. Information from the Sacramento River Flood Control System Evaluation Report, Phases III and IV, was used to determine the locations of structural and piping stability problems in the levees.

The nondamaging water surface elevations of the non-leveed reaches were assumed to be at the existing bank elevations. As a result of the uncertainty of the existing levees along Cache Creek, the PNPs varied from the 3-year (17,000 cfs) to 10-year event (30,000 cfs), and the PFPs varied from the 11-year (31,000 cfs) to 17-year (32,000 cfs) event. For flood events greater than 30,000 cfs (10-year event), the leveed portions of the creek were assumed to fail to the existing ground elevation.

The topography of the lower Cache Creek area around Woodland is very gentle rolling hills to almost flat terrain. As a result of the relatively flat terrain, the 50- , 100- , and 500-year flood plains are characterized by sheet flow flooding with depths from less than 1 foot to 3 feet. The areas of the flood plains for the 50- , 100- , and 500-year events are similar (see Plate 4).

Land Subsidence

Even though land subsidence is not specifically within the scope of work for the westside tributaries study, survey data was compiled and a sensitivity analysis was done to evaluate the impacts of land subsidence on flow capacities in the study reaches. The Corps' survey data for the Woodland area showed about 2.5 feet of localized land subsidence (see Plate 7). The land subsidence decreased to about 0.75 foot at the Cache Creek settling Basin and Yolo Bypass. A hydraulic sensitivity analysis was performed by raising the land area east of the Woodland flood plain about 2.5 feet to reflect the impacts of land subsidence. The hydraulic model showed no change in shape or depth of the resulting flood plains. Therefore, while land subsidence does affect existing levee heights, it does not affect the present shape of the flood plains or the depths of flooding. Plotting the flood plain profile showed that the land gradient is steep enough not to be affected by a land subsidence of 2.5 feet (see Plate 8). However, land subsidence could have greater impact on future levee heights and flood plains if the causes of subsidence is not corrected or reduced.

Basis of Design and Cost Estimates

Reconnaissance-level designs and cost estimates were prepared and evaluated for the following:

- Upstream storage along Cache Creek.
- Upstream detention basin sites for Cache Creek.
- Setback levees and raising existing levees along Cache Creek from Road 94B to Road 102.
- Channel improvements along Cache Creek from Road 94B to Road 102.

The design features of the proposed measures and alternatives are discussed in Appendix C - Basis of Design. The level of detail was sufficient to develop a reconnaissance-level cost estimate. Existing historical data from previous studies by the Corps, other Federal agencies, State, and local agencies were used in the analysis.

The cost estimates included lands and rights-of-way; relocation of utilities; environmental mitigation for fish and wildlife and cultural resources; construction costs of channel and levee work; engineering and design; construction management; and interest during construction.

All land costs for the proposed alternatives were based on fee acquisition. The detailed acquisition cost for the land will be based on the standard government estimate in the feasibility study. The proposed patrol roads would be 12 feet wide and would be located on top of each levee. The right-of-way for the channel improvement alternative would be located on the outside edge of each road. The right-of-way for setback levees would extend 10 feet beyond the landside toe of the levee on either side for maintenance and flood fighting purposes.

The relocation cost included demolition and replacement of railroads, roadways, and bridges and replacement of utilities such as power cables, siphons, pump houses, gauge stations, and irrigation ditches.

Slope protection for the alternatives was based on protecting the banks from scour and erosion. Riprap would consist of an 18-inch layer of angular stone placed on a 6-inch layer of bedding material as designed in accordance with EM 1110-2-1601. The disturbed channel slopes would be seeded to provide erosion protection in areas where riprap would not be required. About 20 pounds of seed per acre would be applied.

Clearing, grubbing, stripping, embankment, road base, slope protection, and other aspects of levee construction were used to develop reconnaissance-level cost estimates. After

the foundation area has been cleared and grubbed, the area would be stripped to a depth of 6 inches to remove low-growing vegetation, organic topsoil, and other ground cover. For raised levees, this clearing would include the crown and landside slope of the embankment to be enlarged.

The costs for fish and wildlife mitigation, cultural resources, engineering and design, and construction management were estimated to be 10 percent, 1 percent, 14 percent, and 8 percent, respectively, of the total construction cost. These estimates were based on similar studies and projects.

The operation and maintenance requirements for the flood control alternatives would be the responsibility of the non-Federal sponsor. The project features would be maintained in accordance with Corps operation and maintenance standards. The non-Federal sponsor could maintain the channel capacity by removing minor sediment deposition and vegetation, repairing any localized erosion of levee side slopes and patrol roads, and removing debris from bridge openings.

Reconnaissance-level designs and first and annual costs were developed for each alternative. Design and cost estimates included structural and nonstructural alternatives. The price level was based on October 1993 prices, and annual costs were based on an interest rate of 8 percent and a 100-year project life. The annual cost for each alternative included interest during construction, as well as operation, maintenance, and replacement costs.

Real Estate

A real estate report is included as Appendix D - Real Estate Report and includes a description of the real estate requirements for the flood control alternatives. The real estate cost estimate included land required for construction, rights-of-ways, and temporary easements. Land cost for environmental mitigation was estimated to be 10 percent of the construction cost. This percentage was based on mitigation costs in previous studies. Further analysis will be required to identified real estate costs for the mitigation features (see real estate memorandum in Appendix D).

Economics

The estimated nondamaging floodflows varied along the reaches of Cache Creek from 17,000 cfs (3-year event) to 30,000 cfs (10-year event).

Flood damage inventories were completed for the 50- , 100- , and 500-year flood plain areas. These flood plain inventories were conducted to identify the location, value, and number of structures in the various land use categories, including residential, commercial, industrial, public, and agriculture. For each structure, information was obtained on structure type and content values, foundation height, type of construction, and number of floors.

The type of flood damages considered were physical damages caused by inundation. Physical damages included damages to, or loss of, buildings and their contents, including furnishings, equipment and fixtures, raw materials, goods in process, and finished products awaiting distribution. Other losses considered were damages to roads, bridges, and utilities.

Physical losses in the flood plain area were estimated for the following land use categories: (1) residential, including single-family, multiple families, and mobile homes; (2) commercial and stores; (3) industrial; (4) public and semipublic; and (5) agricultural. Monetary losses relating to residential included damages to structures and contents. Commercial losses included damages to structures, inventories, and fixtures. Public facilities sustain damages to structures and contents, as well as to roads, bridges, railroads, municipal water systems, and utilities. Damages to semipublic property included structure and content damages to churches and recreation clubs. Agricultural damages included crop and noncrop losses (clean up and damage to irrigation facilities). Additional costs were estimated for flood emergencies for evacuation and reoccupation of homes. These costs were included under emergency costs.

The depth-damage curves used in the analysis were based on FEMA curves, local interviews, and other studies by the Corps and other governmental agencies.

Depths of flooding for the 50- , 100- , and 500-year flood plains were used to estimate total potential flood damages in the study area. These damages were about $139 million, $186 million, and $205 million, respectively. The benefit analysis for the various alternatives assumed October 1993 price levels, a 100-year project life, a 8 percent interest rate, and a base year of 2000. Average annual damages were developed for the without-project condition. The total without-project annual damages were estimated to be $9.7 million (see Table 4.2). (Additional details of the economic analysis are included in Appendix E - Economic Analysis.)

Environmental Resources and Cultural Resources

Available data were used to prepare an environmental evaluation of the existing natural and cultural resources in the study area and the potential impacts due to flood control improvements. The FWS completed a planning aid report and a list of Federally listed threatened and endangered species that may occur in the study area. The planning aid report includes a description of future studies that are needed to better define required environmental mitigation measures and potential restoration work.

Cultural resources work included a literature review to identify known archeological, ethnographic, and historic resources, including Native American sacred or ceremonial sites, within or near the alternative sites.

Table 4.2
Without-Project Average Annual Damages for Woodland and Yolo

Flood Plain Reaches of Woodland and Yolo	Damages ($1,000)
Reach 1	
Single family residential	0.0
Multi-family residential	0.0
Mobile home	0.0
Farmstead S&C	0.4
Commercial	0.2
Industrial	0.0
Public/Semi S&C	0.0
Agriculture crop & clean up	24.5
Automobiles	0.2
Emergency costs	0.8
Roads	4.4
Reach 2	
Single family residential	96.2
Multi-family residential	5.1
Mobile home	44.0
Farmstead S&C	7.2
Commercial	4.1
Industrial	0.0
Public/Semi S&C	5.9
Agriculture crop & clean up	2.7
Automobiles	16.1
Emergency costs	8.8
Roads	2.6
Reach 3	
Single family residential	0.0
Multi-family residential	0.0
Mobile home	0.0
Farmstead S&C	5.2
Commercial	0.0
Industrial	0.0
Public/Semi S&C	0.0
Agriculture crop & clean up	9.5
Automobiles	1.1
Emergency costs	1.2
Roads	3.7
Reach 4	
Single family residential	3274.9
Multi-family residential	297.8
Mobile home	11.9
Farmstead S&C	33.5
Commercial	762.6
Industrial	4012.2
Public/Semi S&C	344.8
Agriculture crop & clean up	103.1
Automobiles	318.3
Emergency costs	206.9
Roads	55.9
Detour	28.9
Total (rounded off)	9,700

FLOOD CONTROL ALTERNATIVES

Based on the flood control measures, alternatives were developed using results of the technical analysis to provide 100- and 200-year levels of flood protection to developed areas along Cache Creek. A no action alternative was also included for comparison.

No Action

Under this alternative, no action would be taken by the Federal Government to reduce flood problems in the study area. Levels of protection provided by the existing levees would remain the same. It is estimated that Woodland and Yolo currently have about a 3 to 10-year level of flood protection. The estimated annual damages from a 100-year event would be about $9.7 million. The estimated total property values in the flood plain are $1.1 billion.

Setback Levee

This alternative would consist of raising and constructing new levees to provide 100-year and 200-year levels of flood protection. In order to limit the channel velocities to about 7 fps to minimize erosion, new levees would be set back from the existing channel along Cache Creek. The proposed height of a new levee would range from 3 to 18 feet. The raised levee heights would range from 1 foot to 8 feet. Slope protection would be provided in high velocity reaches. This alternative would require about 16 miles of setback levees and modification of existing levees for both the 100- and the 200-year alternatives. In order to reduce backwater effects upstream of the bridge crossings, the Southern Pacific Railroad bridge, Cacheville Road bridge, and Road 113 bridge would be replaced with new bridges at elevated heights. In order to reduce the impact to the settling basin, the existing perimeter and training levees of the basin would be raised and the associated cost included in the alternative. Plate 9 shows the physical features of the setback levee alternative.

Aerial photographs were used to establish the setback levee alignment, right-of-way, existing vegetation, natural channel flow patterns, and levee construction away from dense development. The maximum levee height would be set at about 18 feet with a maximum right-of-way width of about 2,000 feet. In areas where gravel operations are adjacent to Cache Creek, levees were set back to match proposed limits or phases of gravel extractions or other existing or planned boundaries. Since all construction activities would be landside and new levees would be constructed on only one side of the channel in many areas, impacts to existing development and riparian vegetation would be reduced.

The proposed right-of-way for levee embankment sections would allow a 12-foot-wide patrol road on top of each levee, 1V:3H side slopes on the water side, and 1V:2H side slopes on the land side, and would extend 10 feet beyond the landside toe of the levee on either side for maintenance and flood fighting purposes.

Channel Improvement

This alternative would include excavating the channel and constructing new levees or raising existing levees to contain the 100- and 200-year design discharge. The alternative would involve widening and/or deepening the existing channel sections to provide additional floodflow capacity. For unleveed reaches, the amount of channel excavation was based on providing 1V:2H side slopes and a minimum vertical distance of one foot between the top of the channel slope and the design water surface elevation as an uncertainty allowance. To minimize bank erosion, slope protection would be provided on reaches with high velocity flows. For channel reaches where it would not be possible to widen the channel, new levees or raising existing levees would take place. The proposed new levees would range from 3 to 11 feet in height. The proposed raised levees would range from 1 to 2 feet in height. This alternative would require about 10 miles of channel excavation and 8 miles of new or raised levees. To reduce the backwater effect upstream of the bridge crossings, the Southern Pacific Railroad bridge, Cacheville Road bridge, and Road 113 bridge would be replaced with new bridges at elevated heights. Plate 10 shows the physical features of the channel improvement alternative.

As shown in Plate 11, channel excavation extends downstream from about Road 94B to Road 102 near the Cache Creek settling basin. The channel bottom widths range from 200 to 400 feet in most reaches in order to limit channel velocities to 6 to 7 feet per second to minimize channel scouring. Along the reaches near the Cache Creek settling basin, channel excavation alone would not contain the floodflows. At these locations, levees would be raised and riprap used to protect slopes from erosion. Additional improvements to the existing training levees in the Cache Creek settling basin were considered necessary to contain the increased floodflows to the Yolo Bypass. Preliminary hydrologic and hydraulic analyses were carried out for the training levees, and cost estimates were included in the alternative.

The proposed right-of-way for channel cut sections assumes a 12-foot-wide patrol road on either side of the channel and 1V:2H side slopes, and would extend 10 feet beyond the outside edge of each patrol road. The proposed right-of-way for levee embankment sections is similar to the setback levees alternative.

COMPARISON OF ALTERNATIVE FLOOD CONTROL ALTERNATIVES

Flood control alternatives were evaluated based on hydraulic, hydrologic, and environmental impacts.

Hydraulic and Hydrologic Impacts

Plates 11 and 12 show 100-year event water-surface profiles for existing and with-project conditions for the two alternatives. Current hydraulic and hydrologic analysis

indicated that neither alternative would have significant detrimental upstream or downstream hydraulic, sediment transport, or channel stability impacts.

As shown on Plate 11, the setback levee alternative does have a minor effect on the existing water-surface elevation at the upstream end of the improvements from Road 94B to Highway 505. The 100- and 200-year water-surface profiles just upstream of the Road 94B bridge are about 0.7 and 0.8 foot higher with the setback levee alternative in place as compared to existing conditions. These increases in water-surface elevation do not significantly increase the flood plain widths. Since there are no identified flood damages in the reach upstream of Road 94B, the setback levee alternative would not significantly impact the area.

As shown on Plate 12, the channel improvement alternative reduces the existing water-surface elevations for floodflow upstream of Road 113 to Road 94B. The 100- and 200-year water-surface profiles just upstream of the Road 94B bridge are about 0.5 and 0.2 foot lower with the channel improvement alternative in place as compared to existing conditions. The improved invert in Plate 12 is the excavated channel for the 100-year alternative.

Overall, both the setback levee and channel improvement alternatives confine floodflows of the 100- and 200-year events within the Cache Creek floodway channel. Both plates show that the left and right banks profiles would be the top of bank elevations along Cache Creek with the alternatives in place.

The levees in the setback levee alternative have been aligned to allow greater in-channel flow rates. For most reaches, the design channel velocities are below 7 fps. In both alternatives where the channel velocities are greater than 7 fps, slope protection has been included to minimize erosion.

Impacts of the increased flows into the Yolo Bypass were determined to be insignificant in both alternatives. This was based on preliminary analyses of the differences in timings of the peak flows entering the Yolo Bypass from Cache Creek, Sacramento River, American River, Feather River, and other tributaries. However, there may be some hydraulic and sedimentation impacts to the flows entering the settling basin. To account for this potential hydraulic impact, perimeter and training levees have been raised and incorporated in the alternatives cost estimates. Detail sedimentation analysis will be evaluated in the feasibility study.

Environmental Impacts

The setback levee alternative would have some temporary adverse impacts to the riparian vegetation due to construction of the new levees. Once the levee system is in place, however, there would be minor impacts on the riparian vegetation. Some riparian vegetation

could be uprooted and carried downstream during a flood event. This natural loss of vegetation would be replaced by seeds disbursed by plants, animals, wind, and water.

The channel improvement alternative would have adverse impacts on riparian vegetation and habitat due to channel excavation and slope protection. Once the channel is excavated, channel maintenance would be required to maintain the design flow capacity. This maintenance would require annual removal of obstructions within the channel such as debris, vegetation, gravel, and sediment. Therefore, future environmental impacts would be greater than the setback levee alternative.

For cost estimating purposes, environmental mitigation costs for the setback levee and the channel improvement alternatives were assumed to be 10 percent of the construction costs based on previous studies mitigation costs. For the setback levee alternative, mitigation could be achieved within the setback levee by planting native grasses, forbs, and small shrubs in areas with no riparian vegetation. Mitigation for the channel improvement alternative would require obtaining an adjacent site. Further analysis of environmental mitigation will be completed during the feasibility study.

ECONOMIC ANALYSIS OF ALTERNATIVES

To determine the economic feasibility of the setback levee and channel improvement alternatives, costs and benefits were determined and compared. Table 4.3 shows the first costs of the two alternatives for 100- and 200-year levels of flood protection. The first costs for the setback levee alternative ranged from $49 million to $54 million for the 100- and 200-year alternatives, respectively. The first cost for the channel improvement alternative ranged from $84 million to $90 million. Table 4.4 shows the total flood control benefits for the 100-year and 200-year events for the setback levees and the channel improvements alternatives. Table 4.5 shows a summary of the economic analysis of the flood control alternatives.

The investment cost includes the interest during construction for the 2-year construction period. The investment costs for the setback levee alternative are $53 million and $58.4 million for the 100- and 200-year alternatives, respectively. For the channel improvement alternative, the investment costs are $91.1 million and $97.8 million.

The annual costs for constructing the setback levee alternative are $4.4 million and $4.9 million for the 100- and 200-year alternatives, respectively. The annual costs for the channel improvement alternative are $7.4 million and $8.0 million.

The annual benefits for the setback levee alternative are $8.0 million and $9.0 million for the 100- and 200-year alternatives, respectively. The channel improvement alternative would provide annual benefits of $9.5 million and $9.8 million.

Table 4.3
First Costs of the Flood Control Alternatives
($ Million)

Description	100-Year Alternative		200-Year Alternative	
	Setback Levee	Channel Improvement	Setback Levee	Channel Improvement
Lands & Damages	15.9	5.4	16.0	6.4
Relocations	5.2	3.3	5.3	3.4
Patrol Roads	0.4	0.4	0.4	0.4
Channels & Canals	7.4	51.4	7.8	54.0
Levees & Floodwalls	11.4	3.0	14.5	4.3
Total Construction Cost	24.4	58.1	28.0	62.1
Fish & Wildlife Mitigation	2.5	6.0	3.0	6.2
Cultural Resources	0.3	0.6	0.3	0.6
Engineering and Design	3.6	8.3	4.0	8.7
Construction Management	2.0	5.2	2.2	5.0
TOTAL FIRST COST [1]	49	84	54	90

[1] Rounded off to nearest million.

Table 4.4
Total Average Annual Equivalent Damages and Benefits for Cache Creek
(1993 Prices, 2000-2100 @ 8.0% interest rate, in $1,000)

	100-year		200-year	
	Setback Levees	Channel Improvements	Setback Levees	Channel Improvements
Total Without Project Damages	$9,700	$9,700	$9,700	$9,700
Total Residual Damages	$2,000	$570	$1,040	$260
Total Inundation Reduction Benefits	$7,700	$9,130	$8,660	$9,440
Advance Replacement of Bridge Benefits	$340	$340	$340	$340
Total Flood Control Benefits	$8,040	$9,470	$9,000	$9,780

Table 4.5
Economic Summary of the Flood Control Alternatives
($ million)

Flood Control Alternatives	First Cost	Investment Cost[1]	Annual Cost[2]	Annual Benefit[3]	B/C Ratio
Setback Levee					
100-year	49.0	53.0	4.4	8.0	1.8
200-year	54.0	58.4	4.9	9.0	1.8
Channel Improvement					
100-year	84.0	91.1	7.4	9.5	1.3
200-year	90.0	97.8	8.0	9.8	1.2

[1] Costs include interest during construction.
[2] Costs include interest and amortization, and operation and maintenance.
[3] Includes $344,000 in benefits for advanced replacement of bridges.

The benefit-to-cost ratios for the setback levee alternative are 1.8 for the 100- and 200-year alternatives. The benefit-to-cost ratios for the channel improvement alternative are 1.3 and 1.2. Therefore, both flood control alternatives are economically feasible at 100-year level of flood protection. A sensitivity analysis showed that these alternatives are also feasible at the 200-year level of flood protection.

ENVIRONMENTAL RESTORATION ALTERNATIVE

One restoration alternative along Cache Creek that has local support involves restoring historic wetlands in abandoned gravel pits. Other proposed restoration alternatives are discussed in Appendix A - Environmental Evaluation, but are not being pursued at this time.

Restore Gravel Pits

Currently, numerous abandoned gravel pits exist along Cache Creek from Capay to just west of Interstate 5 near Yolo 9 (see Figure 4.1). Four irrigation canals, Moore, West Adams, East Adams, and Magnolia, are also located near the gravel pits. These pits range in area from 8 to 50 acres, and in depth from 20 to 30 feet. The pits vary in shape, soil types, and vegetation. All of the abandoned gravel pits are owned by gravel mining industries or private citizens. The local flood control agency and the residents of Yolo County are interested in restoring these pits to seasonal or permanent wetlands.

Figure 4.1 Teichert Aggregate Mining Company located near Cache Creek at the junction of County Roads 96 and 20. Potential site for wetland restoration.

Previous flood control and water development projects in the Central Valley by the Corps and other agencies have caused a serious decline in the biological resources in the valley, including the Yolo Basin and the westside tributaries. This restoration alternative would provide an opportunity to restore some areas in the Central Valley to wetland to increase vegetation and wildlife diversity. Restoration of historic wetlands in the abandoned gravel pits could also benefit the entire creek by diverting some incidental floodflow from Cache Creek, increasing the overall vegetation and wildlife diversity, and increasing the water quality of Cache Creek as a result of water filtering through the restored wetland habitats.

There are 13 gravel pits that are possible candidates for historic wetland restoration (see Plate 13). The restoration alternative could include minor regrading and/or refilling pits or canals, constructing small dams, installing pumps and water control gates, and planting native vegetation. Water would be diverted into the restored wetlands area from Cache Creek and existing canals via gravity flow or pumps.

Engineering feature would include a small rubberized dam (Moore Dam) on Cache Creek similar to the existing Capay Dam. The Moore Dam would retain water only during the non-flood season (see Plates 14 and 15). Habitat features would include water plants, native grasses, small shrubs, and trees. Some native fish would be introduced into the permanent wetlands.

The restored wetlands would support a diverse mixture of riparian woodlands and permanent and seasonal marshes. The benefits of the wetland restoration alternative would include (1) increasing wetland and wildlife habitat for native and migratory waterfowl, (2) recharging ground water supplies, (3) reducing flooding, and (4) generally improving wildlife values along Cache Creek.

The estimated costs to restore historic wetland habitat at these 13 gravel pits are shown in Table 4.6.

Table 4.6
Estimated Costs of Restoring the Gravel Pits[1, 2]

Restoration	Cost ($1,000)
Moore Dam (inflatable rubberized dam)	3,200
Canal modification	260
Habitat restoration	540
Total estimated restoration cost	4,000

[1] The cost does not include land or relocation of utilities.
[2] Cost estimates were provided by Yolo County.

The restoration alternative is based on tangible and intangible environmental benefits. The benefit-to-cost ratio for the environmental restoration alternative is assumed to be 1.0 or greater; therefore, no benefit-to-cost ratio was calculated. This alternative has no known hydraulic impacts on Cache Creek or the Yolo Bypass, and maintenance costs would be minimal.

A complete determination of environmental benefit and cost of this restoration alternative would require more detailed analysis in the feasibility phase of the study. This restoration alternative could also be evaluated under the environmental restoration authority of Section 1135 of the Water Resources Development Act of 1986.

SUMMARY

The setback levee and channel improvement alternatives would reduce flood damages to Woodland and Yolo, are economically feasible, have minimal impacts on hydraulic conditions, and have some adverse environmental impacts. The potential non-Federal sponsors (Yolo County and City of Woodland) support the flood control alternatives.

There appeared to be no Federal interest in the nonstructural methods to protect the YCL and DWWT from flooding in the Willow Slough basin. Future analysis for these and other facilities in the basin would require detailed technical analysis, flood damage assessment, and potential environmental impact.

The environmental restoration alternative of restoring gravel pits appears to have little adverse impact on hydraulic conditions in Cache Creek. The local sponsors support this alternative.

CHAPTER V - LOCAL SUPPORT

NON-FEDERAL SPONSOR

In a letter dated June 9, 1994, the City of Woodland indicated their intent to act as one of the non-Federal sponsors for the Westside Tributaries feasibility study (see Appendix F - Pertinent Correspondence). Yolo County also indicated its willingness to cost share in the feasibility phase with their letter of intent.

PUBLIC INVOLVEMENT

A "Notice of Initiation of a Reconnaissance Study, Westside Tributaries to Yolo Bypass, Flood Control Investigation, California," was sent to Federal, State, county, and city agencies and other interested groups and individuals in May 1993. The purpose of the notice was to identify information on flood control problems and significant natural resources in the areas. Comments received were considered in the development and evaluation of flood control and environmental alternatives for the study area.

On September 21, 1993, the Corps briefed the Yolo County Board of Supervisors on the purposes of the study and the preliminary results to date. The members of the Board asked questions, made comments, and asked that the Corps participate in the Yolo-Solano County Flood Control Task Force. The meeting was also open to other public agencies, organizations, and interested individuals in the study areas. Comments focused on flooding along Cache Creek and Willow and Dry Sloughs, land subsidence, gravel mining, and affects of the project on the settling basin.

The Corps attended several subsequent meetings of the Yolo-Solano Flood Control Task Force. At the December 8, 1993, and April 7, 1994 meetings, the Corps presented the preliminary results and status of the westside tributaries study.

On April 15 and May 6, 1994, the Corps held workshops in Woodland to present the study results and discuss the procedures to complete the reconnaissance phase and initiate the feasibility phase of the study. The meeting was attended by representatives from the Corps, other Federal agencies, State, counties of Yolo and Solano, cities of Woodland and Davis, public utilities, and private engineering firms. A number of questions were raised including impacts on the Cache Creek settling basin, Corps versus FEMA flood plain delineations, flood protection for the Yolo County Landfill and Davis Waste Water Treatment Plant, maintenance of the completed project, cost-sharing, and funding.

The Corps also presented the study findings to the Woodland City Council and Yolo County Board of Supervisors, members of the Water Resources Association of Yolo County, and public on April 20, May 3, and May 5, 1994, respectively.

During feasibility studies, a public involvement program would include information summaries, meetings with special interest groups, and a formal public meeting to be held near the conclusion of the study.

CHAPTER VI - FEASIBILITY PHASE STUDIES

REQUIRED STUDIES

A large number of studies will be required during the feasibility phase of the investigation. A scope of work, cost estimate, and schedule for the feasibility studies have been prepared and are referenced in the Feasibility Cost-Sharing Agreement (FCSA). The FCSA is between the Department of the Army (represented by the Sacramento District Engineer) and the non-Federal sponsors (City of Woodland and Yolo County) and identifies the equal sharing of costs for the feasibility study. Accompanying submission of the final FCSA and Initial Project Management Plan (IPMP) for approval will be letters of intent from the non-Federal sponsors stating that the FCSA is acceptable and that the sponsors will sign the agreement upon certification of the reconnaissance report. (A draft FCSA and IPMP are included in Appendixes G - Draft Feasibility Cost-Sharing Agreement and H - Initial Project Management Plan.)

STUDY MANAGEMENT

The non-Federal sponsors will be involved in study management. In order to manage a cost-shared study, an Executive Committee and a Study Management Team will be formed. This management structure will be formalized in the FCSA.

The Study Management Team will include the Corps and the non-Federal sponsors. This team will develop the studies, guide in their accomplishment, and participate in selection of potential solutions. The team will be directly involved in establishing mutual roles and in focusing on the critical issues of flood control. Corps representatives will include the study manager, the Chief of Sacramento River Basin Branch, and other technical specialists. The team will recommend to the Executive Committee the tasks to be conducted and extent of planning and evaluation to be carried out in the feasibility phase. The team will also report the results of studies to the Committee and recommend alternative courses of action for project implementation.

The Executive Committee will include the District Engineer, the Chief of Planning Division, and the Deputy District Engineer for Project Management. The sponsors, along with primary technical advisors, will be equal partners with the Corps representatives on the Committee. The District Engineer and his counterpart with the City of Woodland and Yolo County will co-chair the Committee.

The Executive Committee will participate in Issue Resolution Conferences (IRC) and ratify decisions made by the Study Management Team. The Committee is also responsible for resolving any disputes that may arise during the study. The Committee will agree on the solutions and study direction, which may include termination. At least one IRC will be held

prior to the public distribution of the draft feasibility report to ensure that all issues are resolved prior to submitting the final report to higher authority. Additional IRC's will be held, as required, throughout the study to resolve any problems that may arise.

A project manager (PM) will be assigned to this study prior to signing the FCSA. The PM's role is to manage the overall project from the development of the FCSA through construction and allocate funds for accomplishment of tasks. The PM will be the primary point of contact for the non-Federal sponsors for items regarding the FCSA, policy issues, budgetary requests, schedule, and overall project development.

The Corps study manager will be required to perform both the general supervision of personnel involved in the study and the management of the study itself. He/she will ensure that funds are allocated to the proper organizational elements and that appropriate analyses are conducted to develop the information needed to evaluate the resource problems in the study area. He/she will also direct the flow of technical information between the Corps and the non-Federal sponsors in order to accomplish the work in an efficient and timely manner.

FINANCIAL ANALYSIS

Feasibility Phase

The feasibility phase will be cost-shared 50 percent Federal/50 percent non-Federal. Fifty percent of the non-Federal share or 25 percent of the total project cost can be in-kind services.

Construction Phase

The cost of constructing the project will be shared in accordance the Water Resources Development Act of 1986. During construction of a project, the non-Federal sponsors must pay 5 percent of the costs assigned to flood control. In addition, the sponsors must provide all lands, easements, rights-of-way, relocations, and disposal areas (LERRD's). If the total for the two of these costs is less than 25 percent added cash contribution is needed to make the total non-Federal share equal to 25 percent of the total project cost. Maximum contribution is 50 percent of the total project cost. For environmental restoration, the cost sharing is 75 percent Federal and 25 percent non-Federal with credit given for LERRD's.

CHAPTER VII - DISCUSSION AND CONCLUSIONS

In 1992, the Corps completed a reconnaissance study of the Yolo Bypass and adjacent tributaries. This 1992 study did not identify any feasible flood control alternatives. However, the study indicated that the flooding problems of Woodland, Davis, and surrounding communities could be caused by the westside tributaries such as Cache Creek, Willow Slough, and Putah Creek. This Westside Tributaries reconnaissance study was initiated in April 1993 at the request of the Yolo County Board of Supervisors. In the Energy and Water Development Appropriations Act of 1993 (Public Law 102-377), the Congress directed the Corps, to conduct a reconnaissance study to investigate flooding problems along the westside tributaries.

Flooding in the study area is caused by runoff from high-intensity, short duration, rainstorms during the winter and spring. Historically, Cache Creek exceeded the design channel capacity of 30,000 cfs in 1955. In 1958 and 1983, Cache Creek rose to the top of both levees and overflowed its banks toward Woodland and Davis. In 1983, there was at least one levee break downstream from Road 102. Federal, State, and local agencies patched levee boils at that time to prevent additional levee breaks along both sides of the Cache Creek levees. The flood of record for Cache Creek at the Yolo gauge was the 1983 storm event of 33,000 cfs (20-year flood event).

The objectives of this study were to investigate the flood problems in the study area and develop potential solutions to these problems. The analysis focused on Cache Creek since the major flood threat to developed areas in Woodland and Yolo is from Cache Creek. There are few developed areas in the Willow Slough basin so flooding causes minimal damages, and technical analyses showed that developments in the Putah Creek basin currently provide 100-year level of flood protection. As a result, further studies of Putah Creek were not pursued. According to the Sacramento River Flood Control System Evaluation project, the heights of portions of the levees along Cache Creek, Willow Slough, and Putah Creek do not meet original design criteria. The analysis indicates that the height deficiency stems from regional land subsidence in the study area. However, the overall impact to the depth of the flooding in Woodland and Yolo area is minimal at this time since the topography of the study area has a steep slope gradient.

Numerous flood control measures were evaluated, including nonstructural methods, upstream storage, upstream detention basins, channel improvement, and levee modification/setback levees. In addition to the flood control measures, environmental restoration measures were developed. Numerous sources of data were reviewed, including earlier detailed studies of a multipurpose dam at the Blue Ridge site in the upper Cache Creek area. Due to lack of interest by the local sponsors at that time and the high construction cost, this dam was not considered further. The upstream detention basins were also not considered further due to inadequate flood storage, unstable soil conditions, large

land acquisition requirements, and high environmental mitigation costs. The nonstructural methods were considered economically infeasible and impractical for Woodland and Yolo.

Several technical studies were performed. Results of the flood plain studies verify the existence of a serious flood threat to the city of Woodland and the town of Yolo. The formulation of alternatives resulted in two economically feasible flood control plans that would provide increased levels of flood protection to Woodland and Yolo. These two structural flood control alternatives consist of setback levee and channel improvement. The benefit-to-cost ratios for the two levels of flood protection are shown in Table 7.1. The estimated first costs for the flood control alternatives range from $49 million to $90 million for the 100-year and 200-year events.

Table 7.1
Summary of the Benefit-to-Cost Ratios

Alternative	100-year	200-year
Setback Levee	1.8	1.8
Channel Improvement	1.3	1.2

Environmental restoration in the Yolo Basin would contribute to international, regional, and local efforts to protect wetlands habitat. Currently, numerous abandoned gravel pits exist along Cache Creek from Capay to just west of Interstate 5 near Yolo. Several pits are located within the area of the proposed setback levee and channel improvement alternatives. All of the abandoned gravel pits are owned by gravel mining industries or private citizens. The local flood control agency and the residents of Yolo County have expressed interest in restoring these pits to seasonal or permanent wetlands. Information presented in this reconnaissance report could serve as a basis for further development and refinement of the gravel pit restoration alternative. Another option would be to develop the gravel pit restoration alternative under the authority of Section 1135 of the Water Resources Development Act of 1986.

Further detailed planning studies would involve inventory of structures within the flood plains, plan formulation, design and cost estimates, real estate studies, environmental mitigation requirements, and economic analysis.

CONCLUSIONS

Based on the studies in this report, it is concluded that:

- A serious flood threat exists to the City of Woodland and the Town of Yolo from Cache Creek overflow.

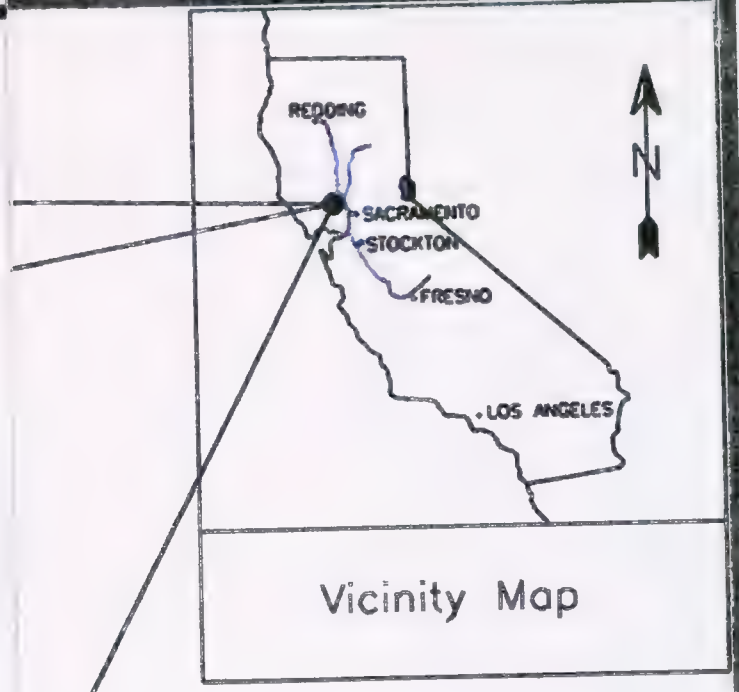
- There are economically justified alternatives that would increase the levels of flood protection and provide flood damage reduction to development in the study area.

- Yolo County and the City of Woodland have indicated that they support providing increased flood protection and are willing and capable of sharing the costs of feasibility studies.

CHAPTER VIII - RECOMMENDATION

The results of this reconnaissance study indicate that there is a Federal interest in at least one potential flood control alternative and one potential environmental restoration alternative for the Westside Tributaries to Yolo Bypass. These alternatives have local support, appear economically feasible, and have local sponsors who are willing to cost share the feasibility phase at this time. Therefore, I recommend that feasibility studies for the Westside Tributaries to Yolo Bypass study be approved.

John N. Reese
Colonel, Corps of Engineers
District Engineer



Vicinity Map

LEGEND

CACHE CREEK BASIN

PUTAH CREEK BASIN

WILLOW SLOUGH BASIN

SCALE IN MILES

0 5 10 15 20

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

GENERAL and VICINITY MAP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 1

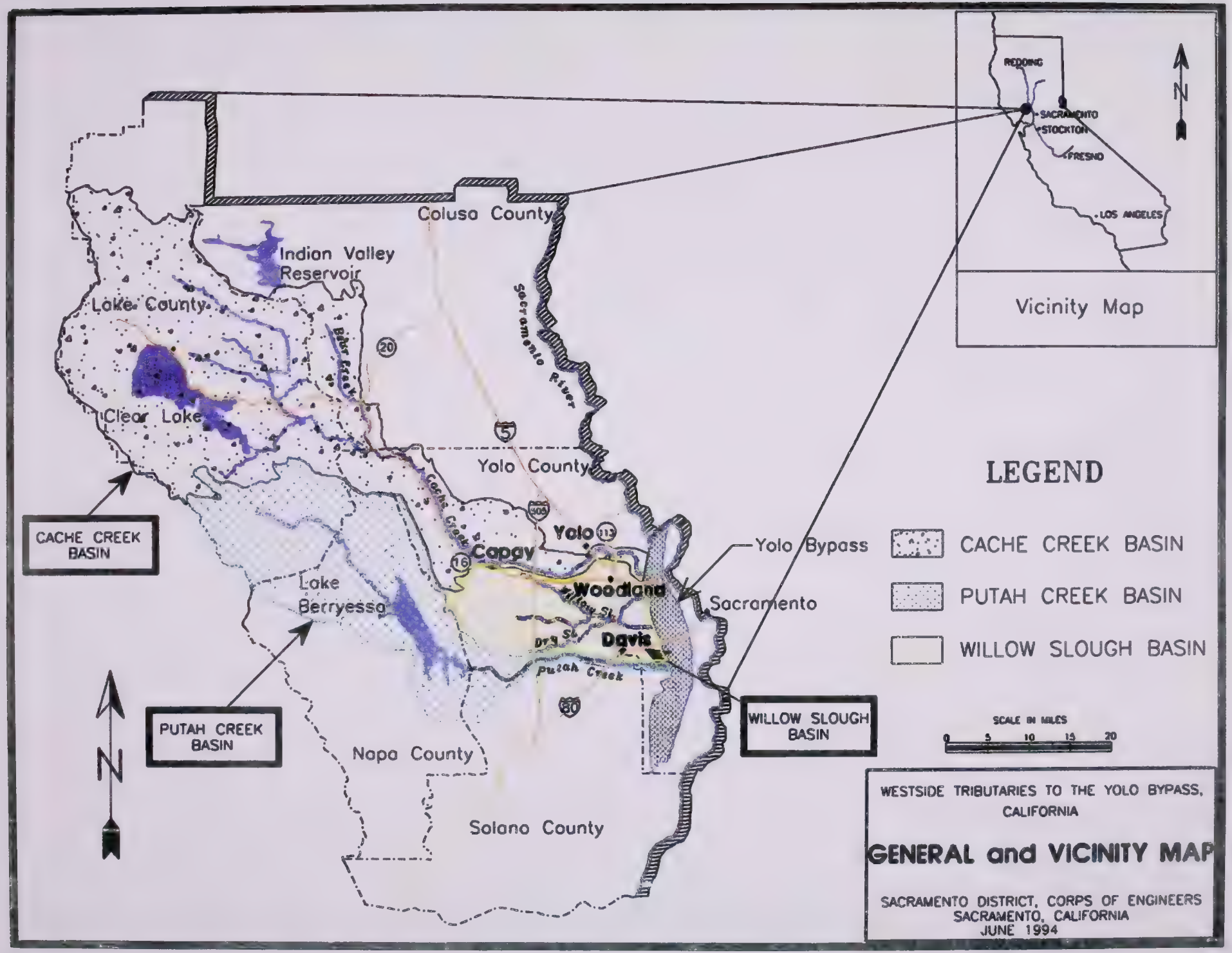

Colusa County
Indian Valley Reservoir
Lake County
Clear Lake
Sacramento River
Yolo County
Cache Creek
Capay
Yolo
Woodland
Yolo Bypass
Sacramento
Lake Berryessa
Willow Sl.
Dry Sl.
Davis
Putah Creek
Napa County
Solano County
CACHE CREEK BASIN
PUTAH CREEK BASIN
WILLOW SLOUGH BASIN
N
REDDING
SACRAMENTO
STOCKTON
FRESNO
LOS ANGELES
Vicinity Map
LEGEND
CACHE CREEK BASIN
PUTAH CREEK BASIN
WILLOW SLOUGH BASIN
SCALE IN MILES
0 5 10 15 20
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA
GENERAL and VICINITY MAP
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 1

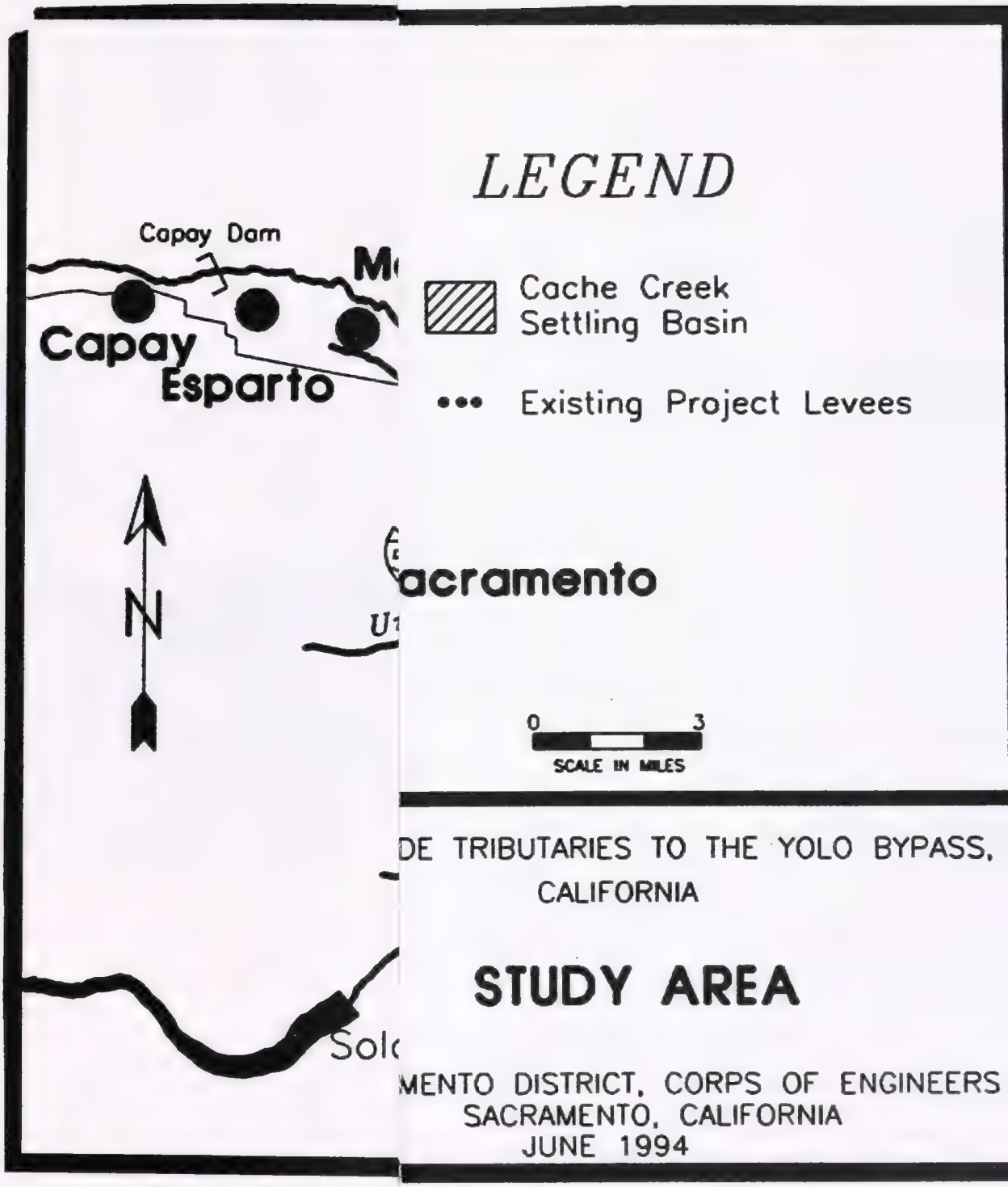

LEGEND
Cache Creek
Settling Basin
Existing Project Levees
Capay Dam
Capay
Esparto
N
acramento
0
3
SCALE IN MILES
DE TRIBUTARIES TO THE YOLO BYPASS,
CALIFORNIA
STUDY AREA
MENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 2

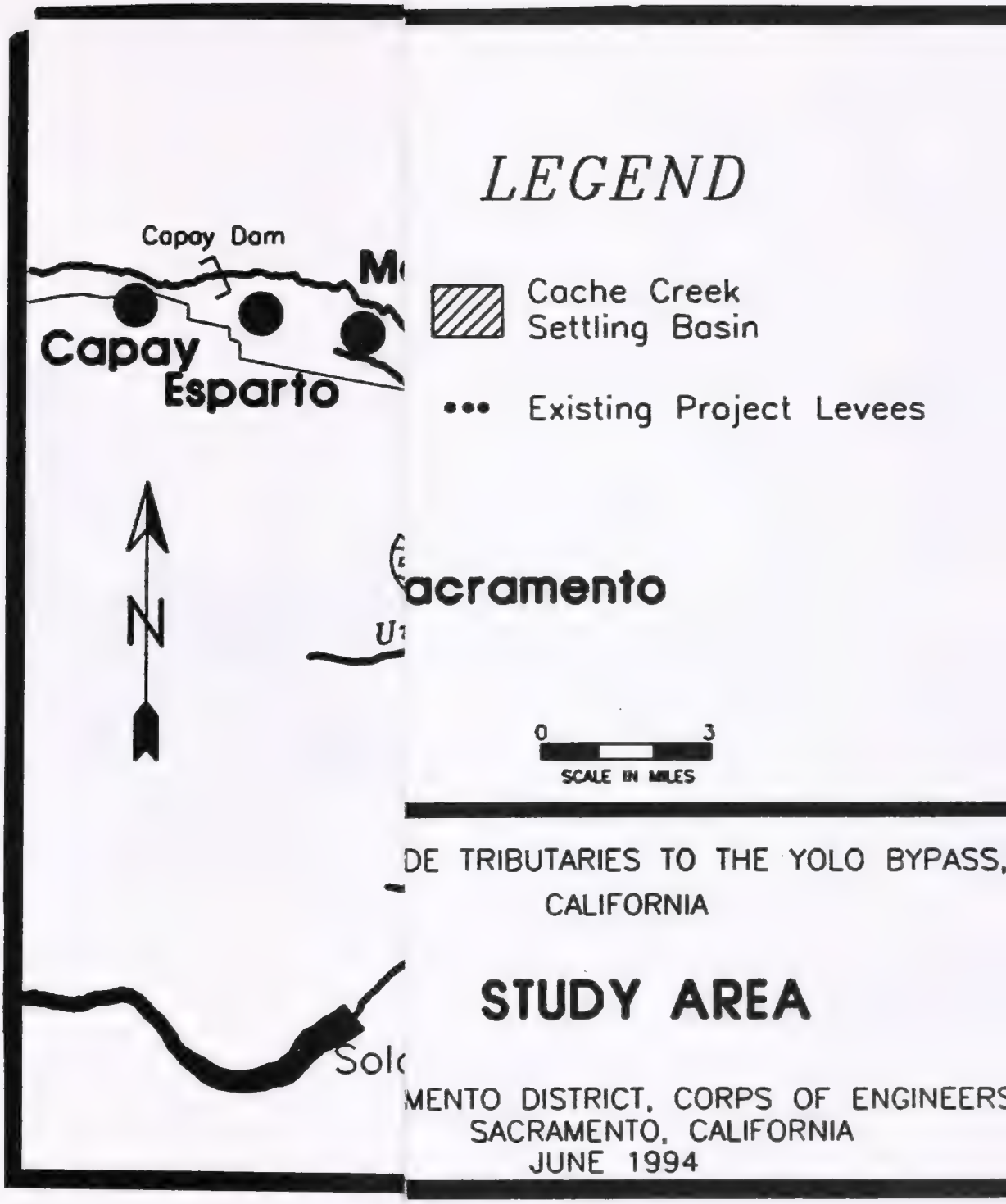

LEGEND
Capay Dam
Capay
Esparto
Cache Creek
Settling Basin
Existing Project Levees
N
0
3
SCALE IN MILES
DE TRIBUTARIES TO THE YOLO BYPASS,
CALIFORNIA
STUDY AREA
MENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 2

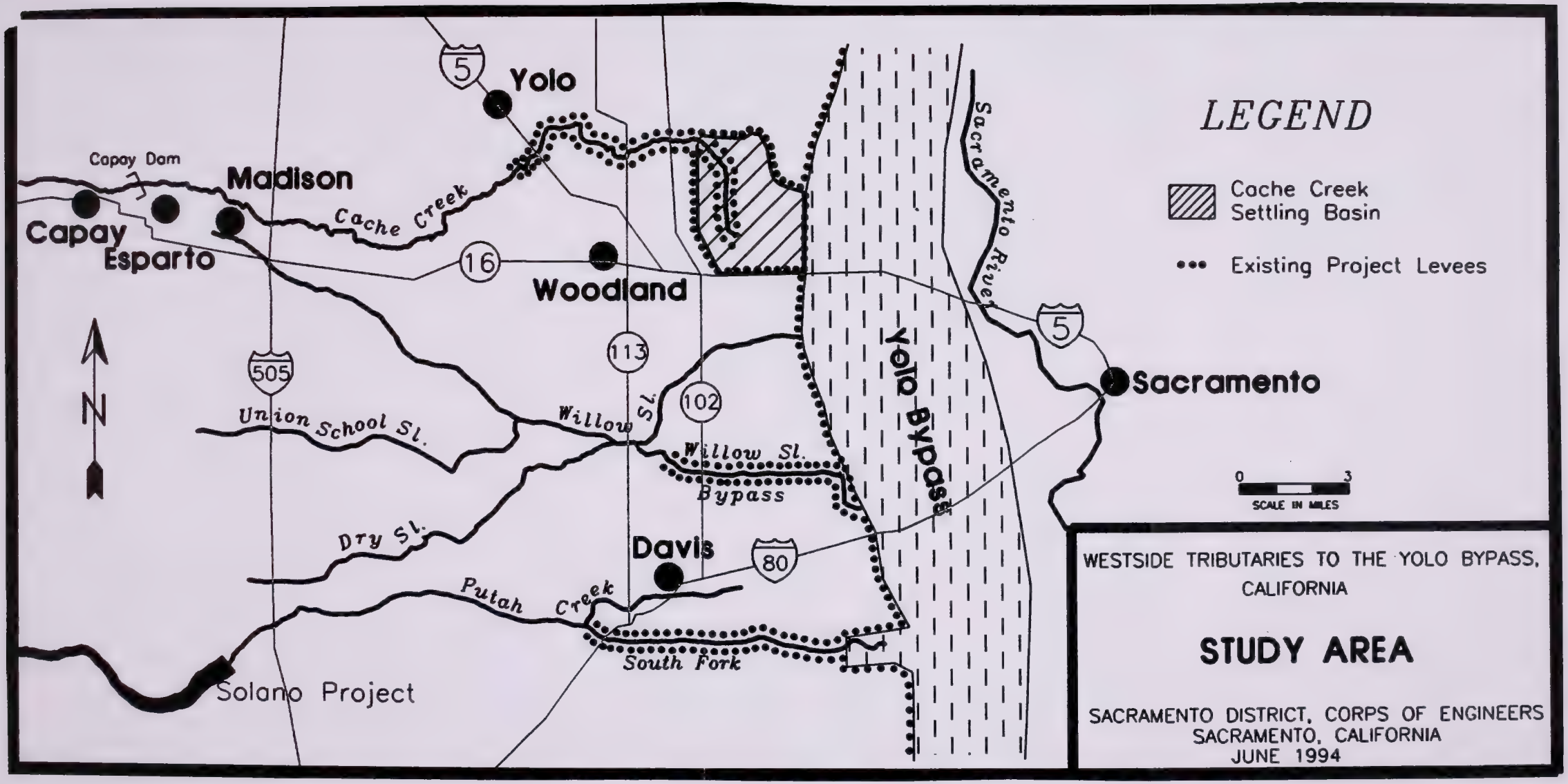
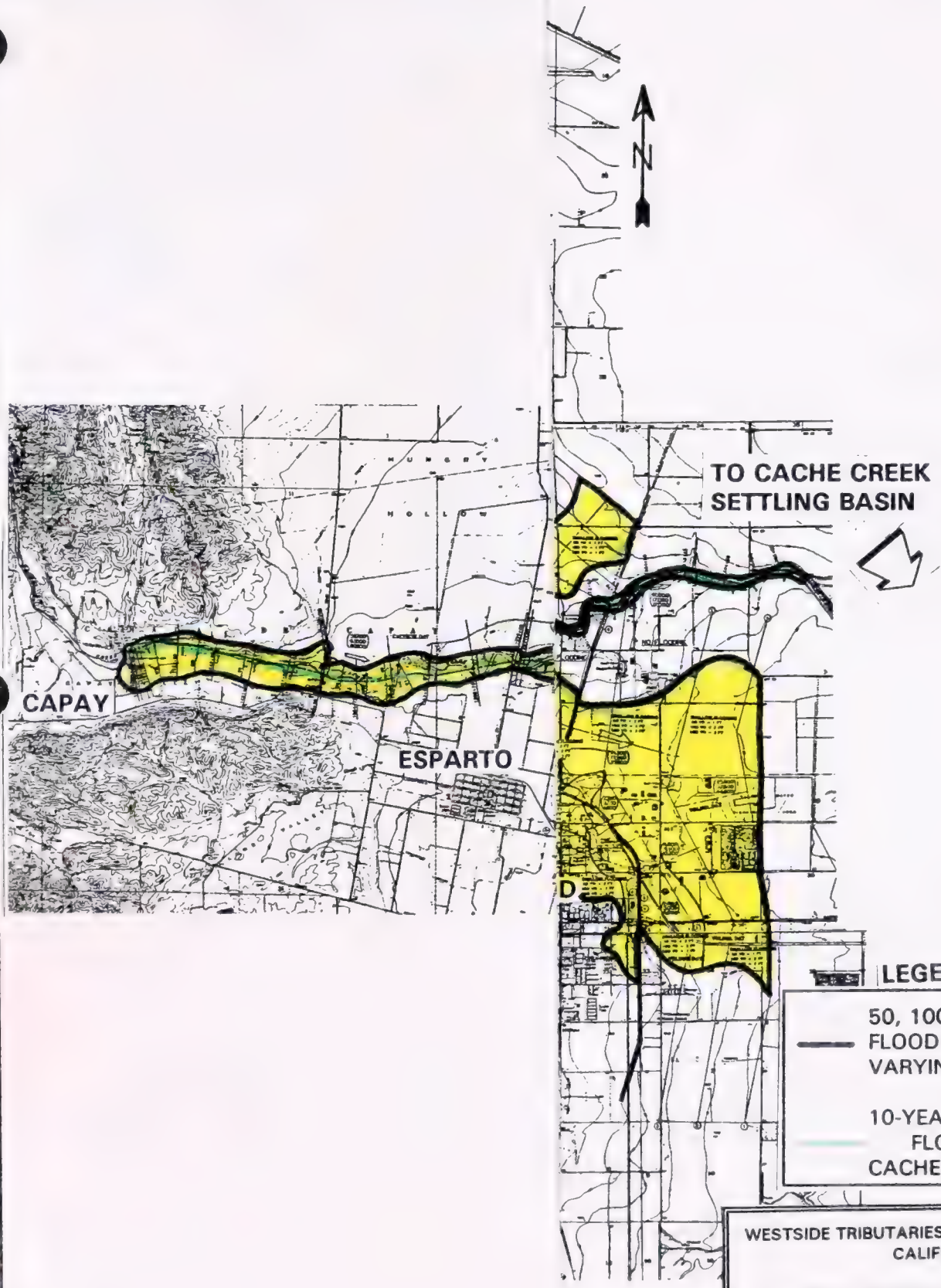

Yolo
Capay Dam
Madison
Capay
Esparto
Cache Creek
16
Woodland
113
505
102
Union School Sl.
Willow Sl.
Willow Sl.
Bypass
Dry Sl.
Davis
80
Putah Creek
South Fork
Solano Project
N
Yolo Bypass
Sacramento River
5
Sacramento
LEGEND
Cache Creek Settling Basin
Existing Project Levees
0
3
SCALE IN MILES
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA
STUDY AREA
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 2

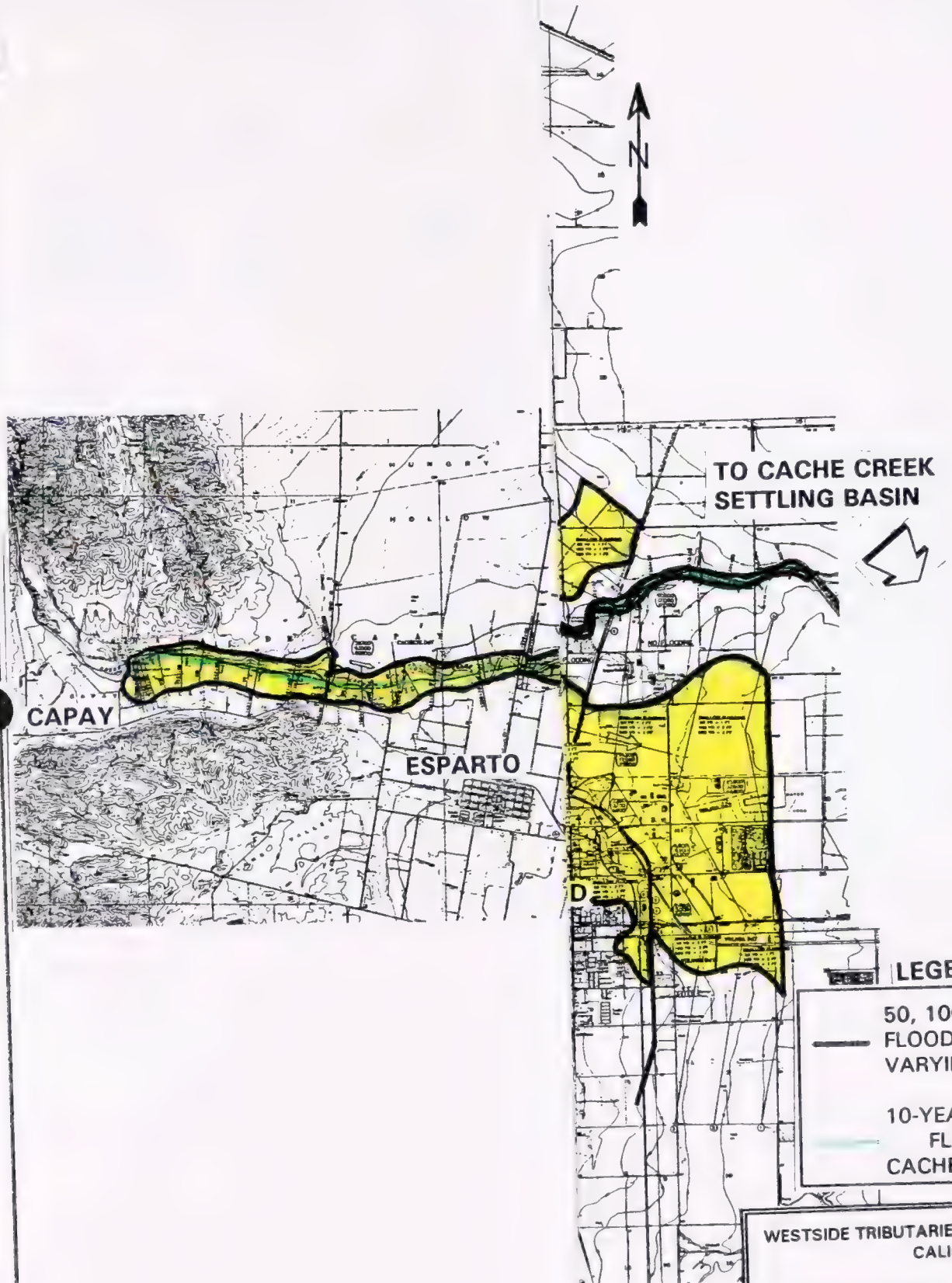


WESTSIDE TRIBUTARIES TO THE YOLO BYPAS
CALIFORNIA

CACHE CREEK FLOOD PLAIN

SACRAMENTO DISTRICT, CORPS OF ENGINEE
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 3



LEGEND

50, 100, 500 YEAR
FLOOD PLAINS WITH
VARYING DEPTH

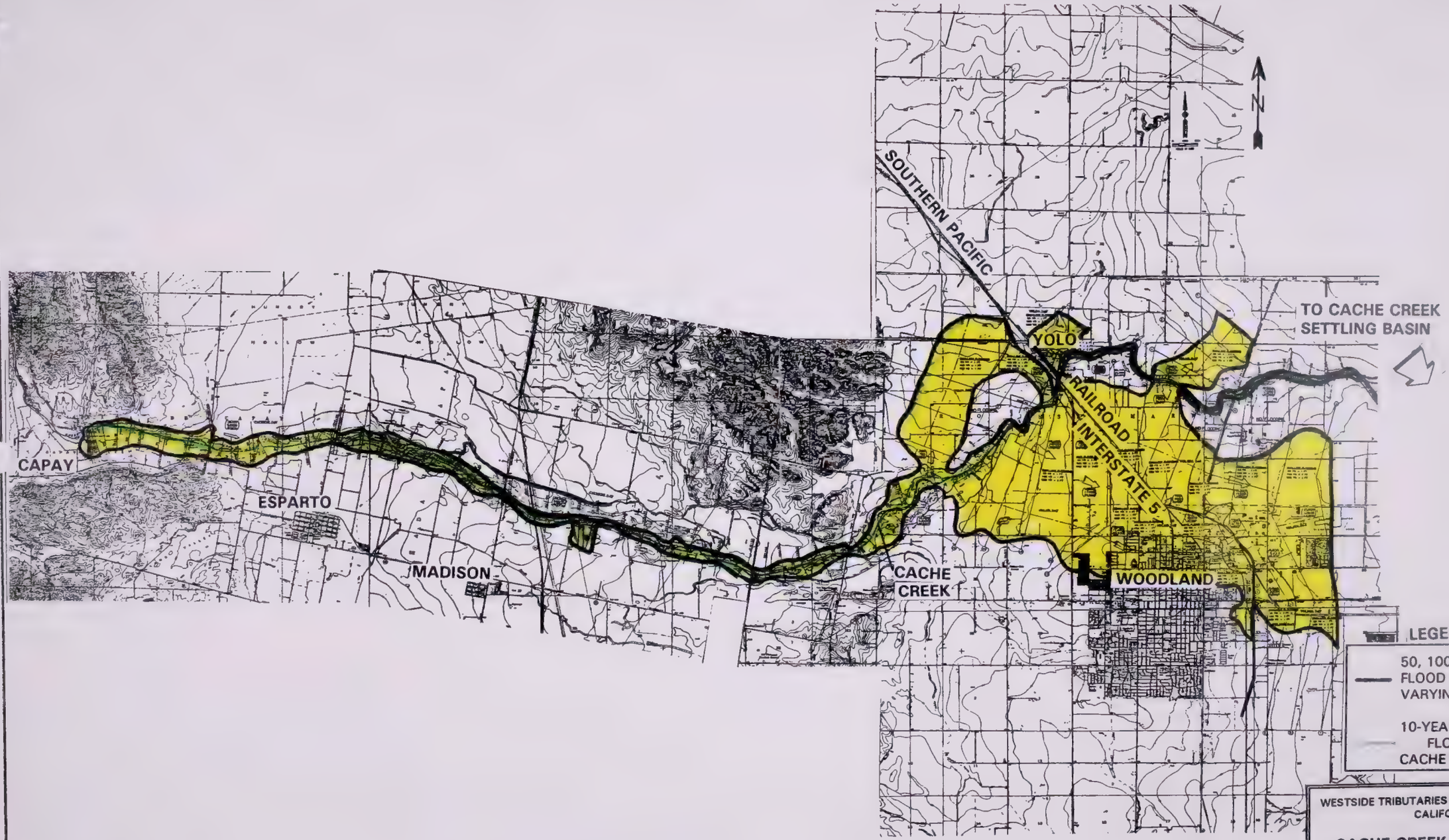
10-YEAR NON-DAMAGI
FLOW OF
CACHE CREEK CHANNE

WESTSIDE TRIBUTARIES TO THE YOLO BYPA
CALIFORNIA

CACHE CREEK FLOOD PLAI

SACRAMENTO DISTRICT, CORPS OF ENGINE
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 3

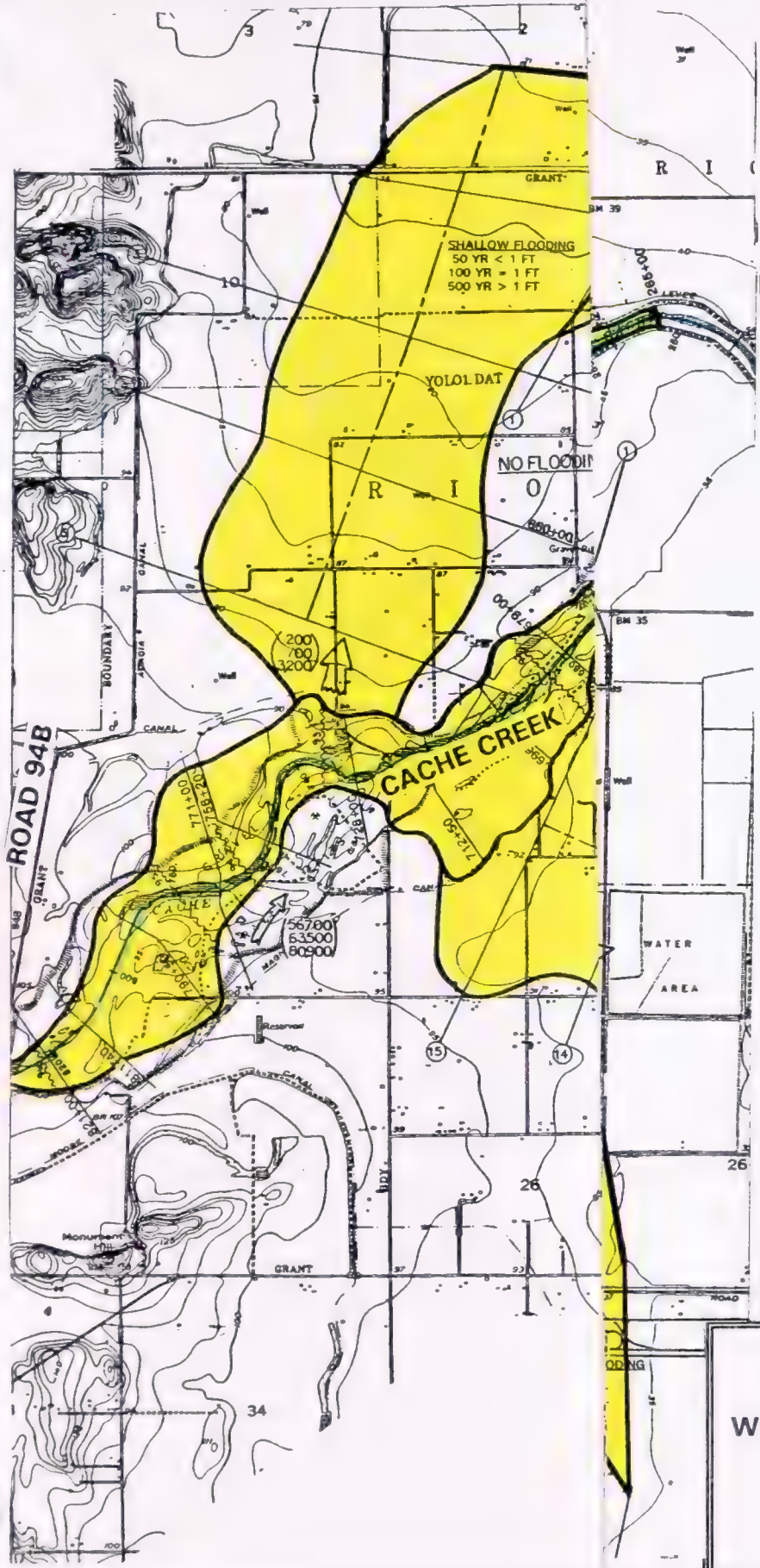


WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

CACHE CREEK FLOOD PLAIN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 3



LEGEND

FLOW FOR FLOOD EVENT

50 YR	13,900
100 YR	17,400
500 YR	24,300

DEPTH OF FLOOD

50 YR < 1 FT
100 YR = 1 FT
500 YR > 1 FT

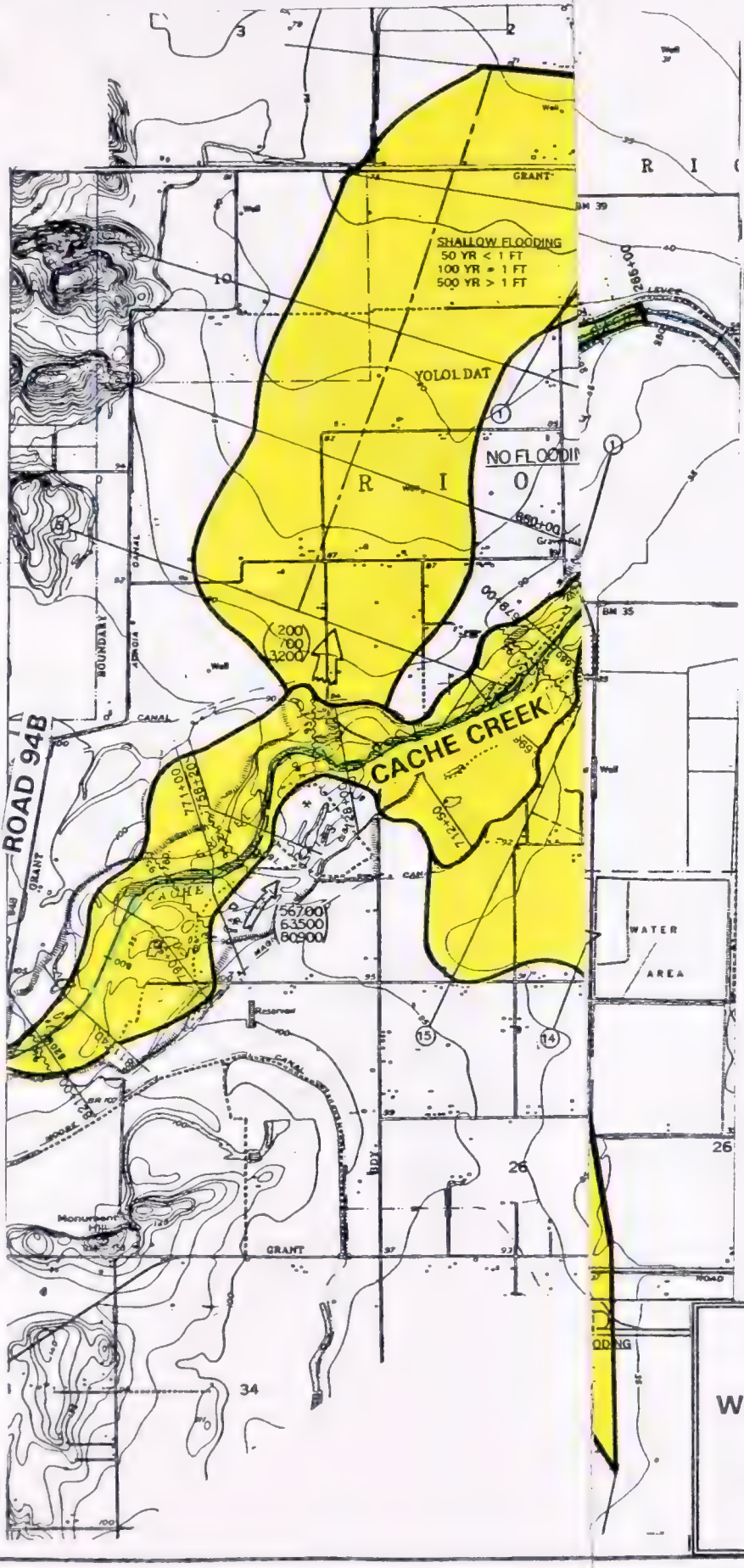
FLOOD FLOW

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

WOODLAND AND YOLO FLOOD PLA
50, 100, & 500 YEAR

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 4



LEGEND

FLOW FOR FLOOD EVENT

50 YR	13,900
100 YR	17,400
500 YR	24,300

DEPTH OF FLOOD

50 YR < 1 FT
100 YR = 1 FT
500 YR > 1 FT

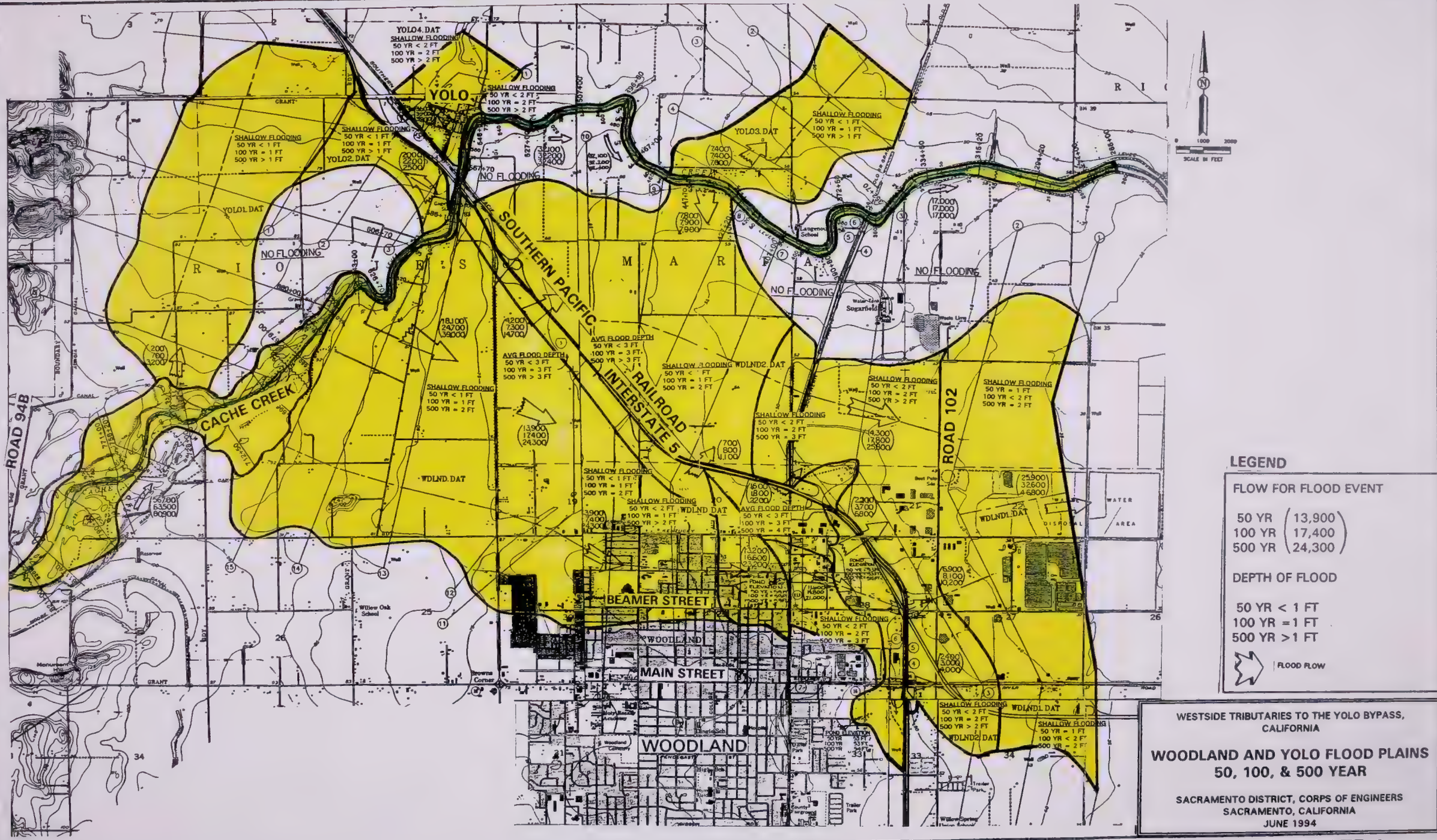
FLOOD FLOW

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

WOODLAND AND YOLO FLOOD PLA
50, 100, & 500 YEAR

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 4

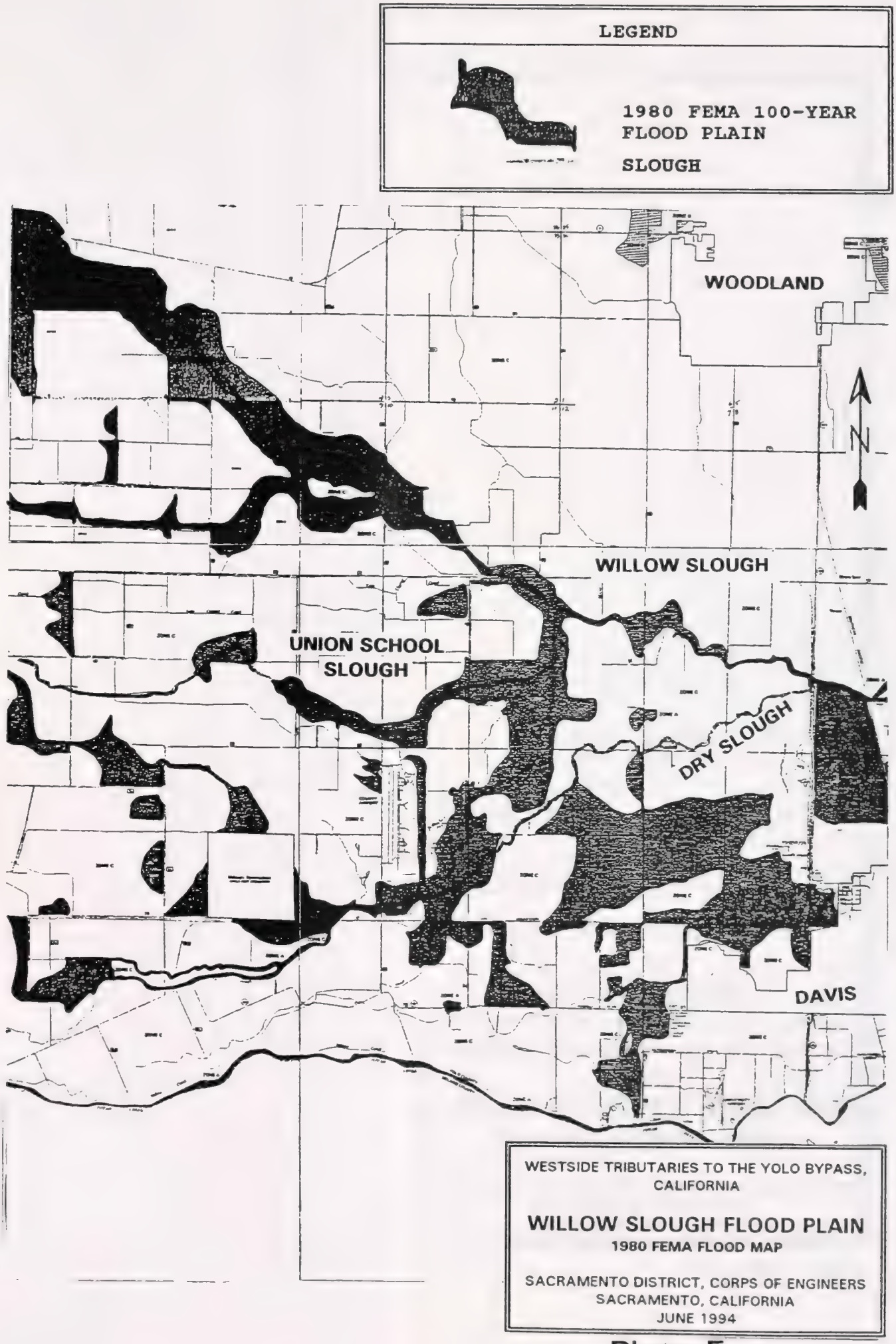


WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

WOODLAND AND YOLO FLOOD PLAINS 50, 100, & 500 YEAR

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 4



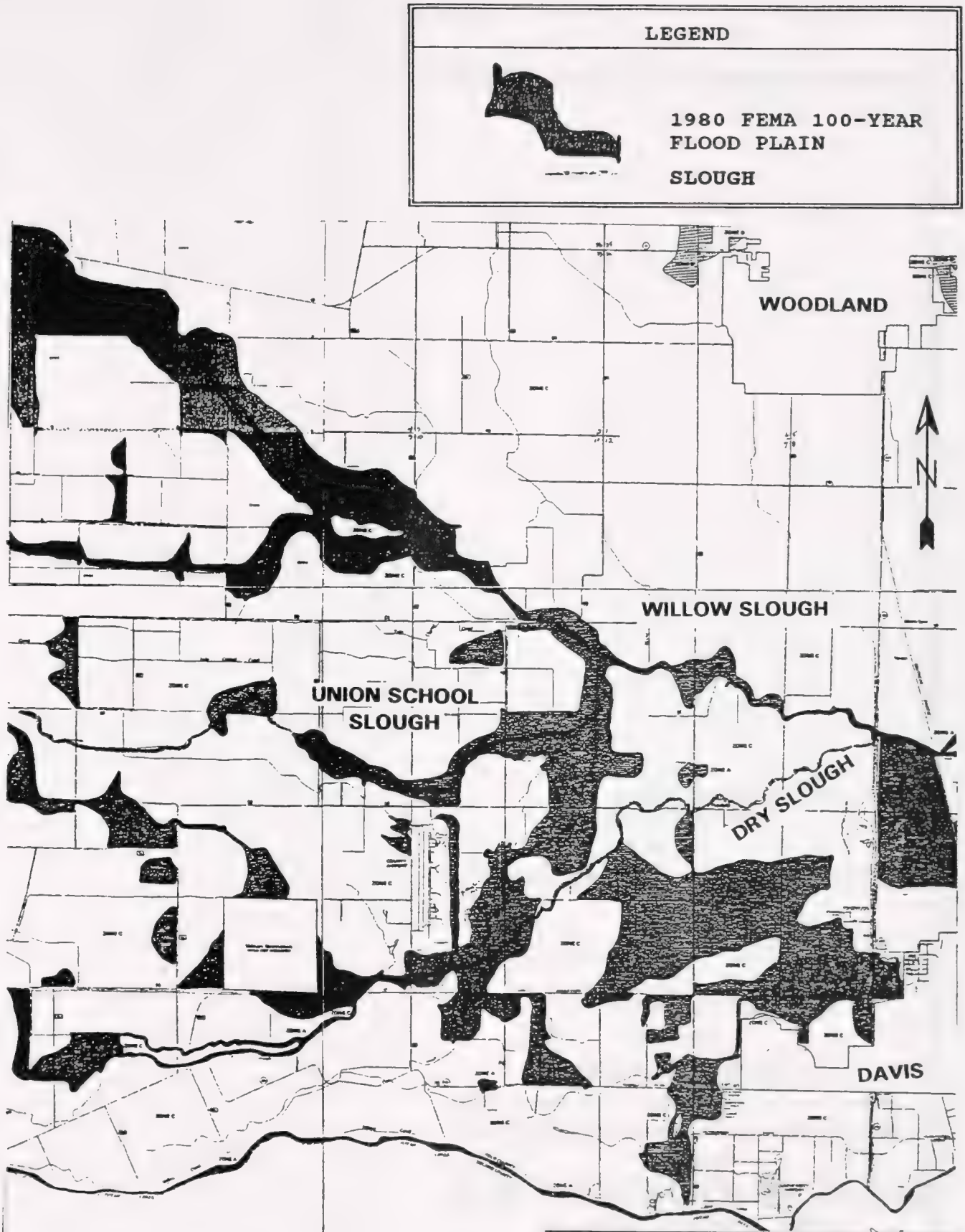
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

WILLOW SLOUGH FLOOD PLAIN

1980 FEMA FLOOD MAP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 5



WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

WILLOW SLOUGH FLOOD PLAIN

1980 FEMA FLOOD MAP

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 5

oss

LEGEND

CHANNEL IMPROVEMENTS

LEVEE MODIFICATIONS

DETENTION/RESERVOIR

SCALE IN MILES

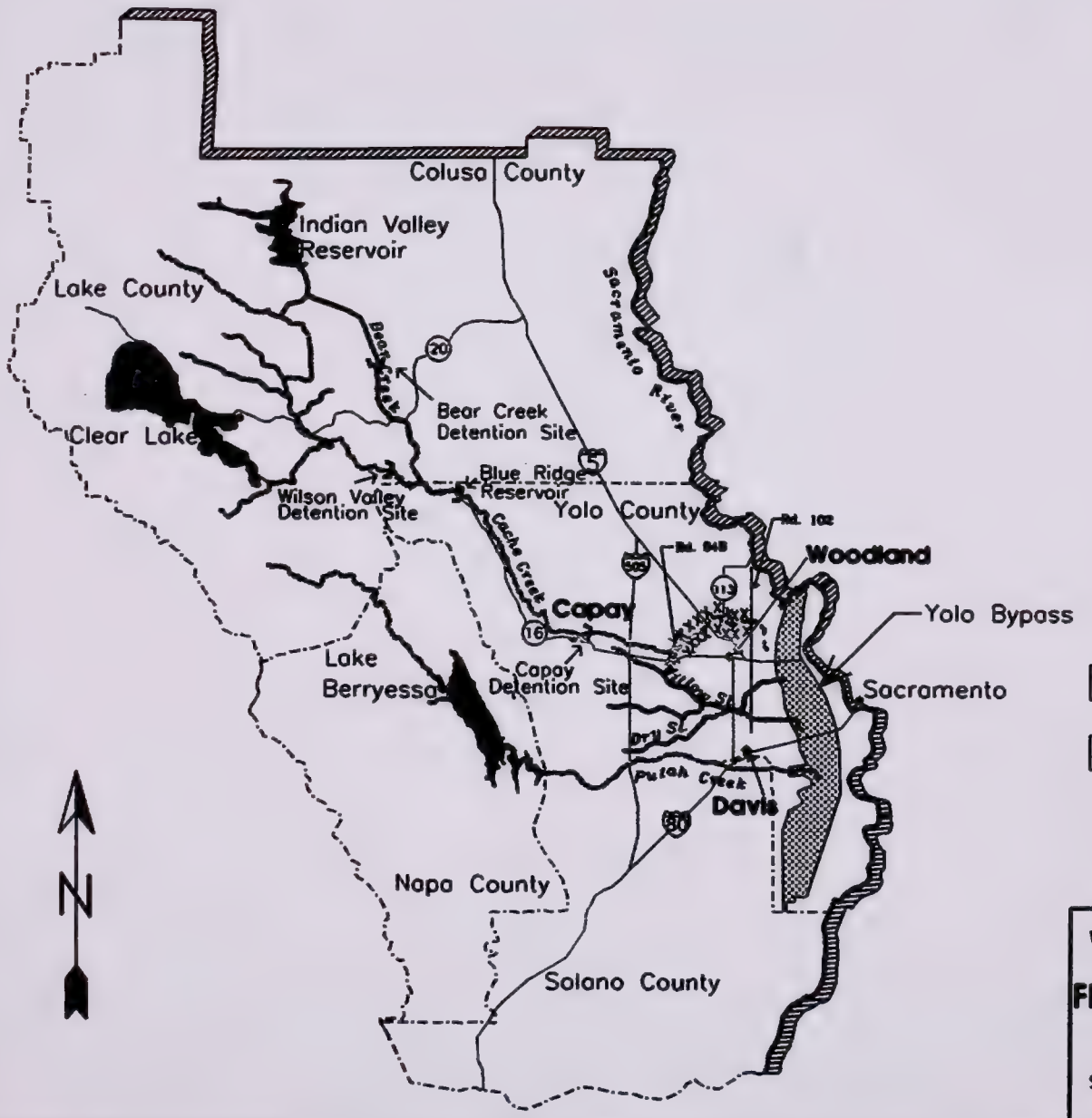
0 5 10 15 20

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

FLOOD CONTROL MEASURES IN THE STUDY AREA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 6a



LEGEND

- CHANNEL IMPROVEMENTS
- LEVEE MODIFICATIONS
- DETENTION/RESERVOIR

SCALE IN MILES

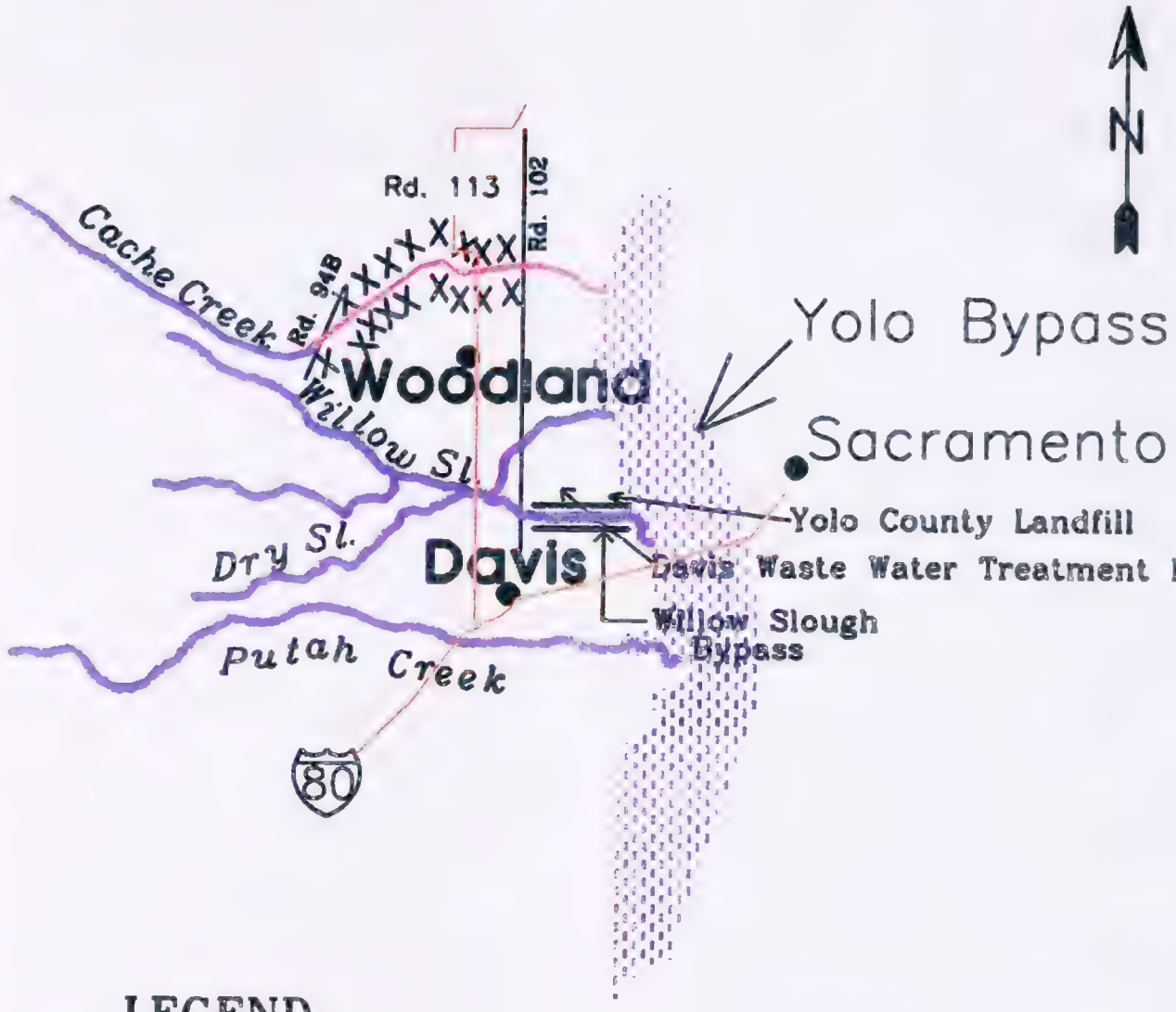
0 5 10 15 20

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

FLOOD CONTROL MEASURES IN THE STUDY AREA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 6a



LEGEND

CHANNEL IMPROVEMENTS

LEVEE MODIFICATIONS

SCALE IN MILES

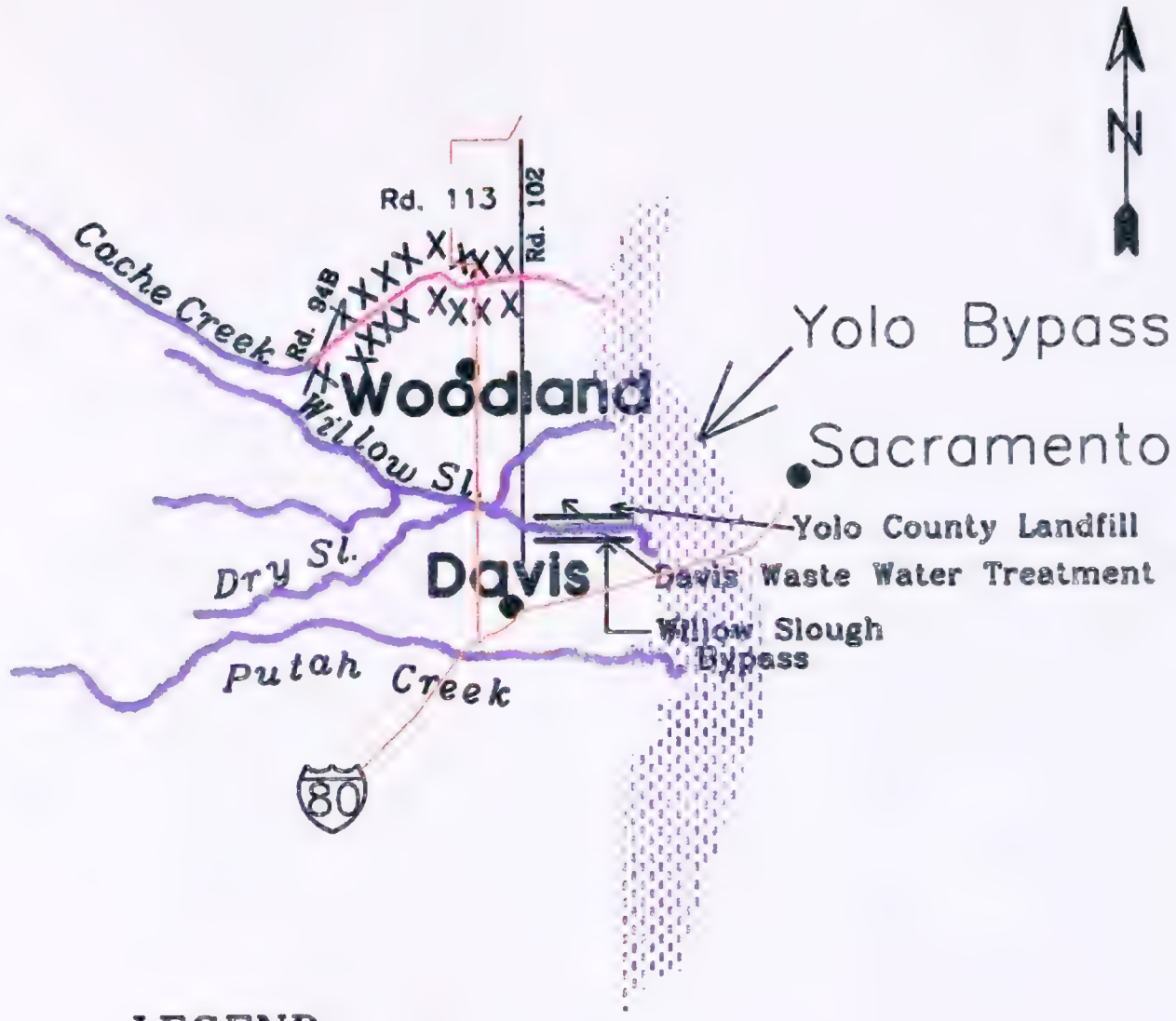
0 5 10 15 20

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS
CALIFORNIA

FLOOD CONTROL MEASURE ALONG CACHE CREEK

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 6



LEGEND

CHANNEL IMPROVEMENTS

LEVEE MODIFICATIONS

SCALE IN MILES

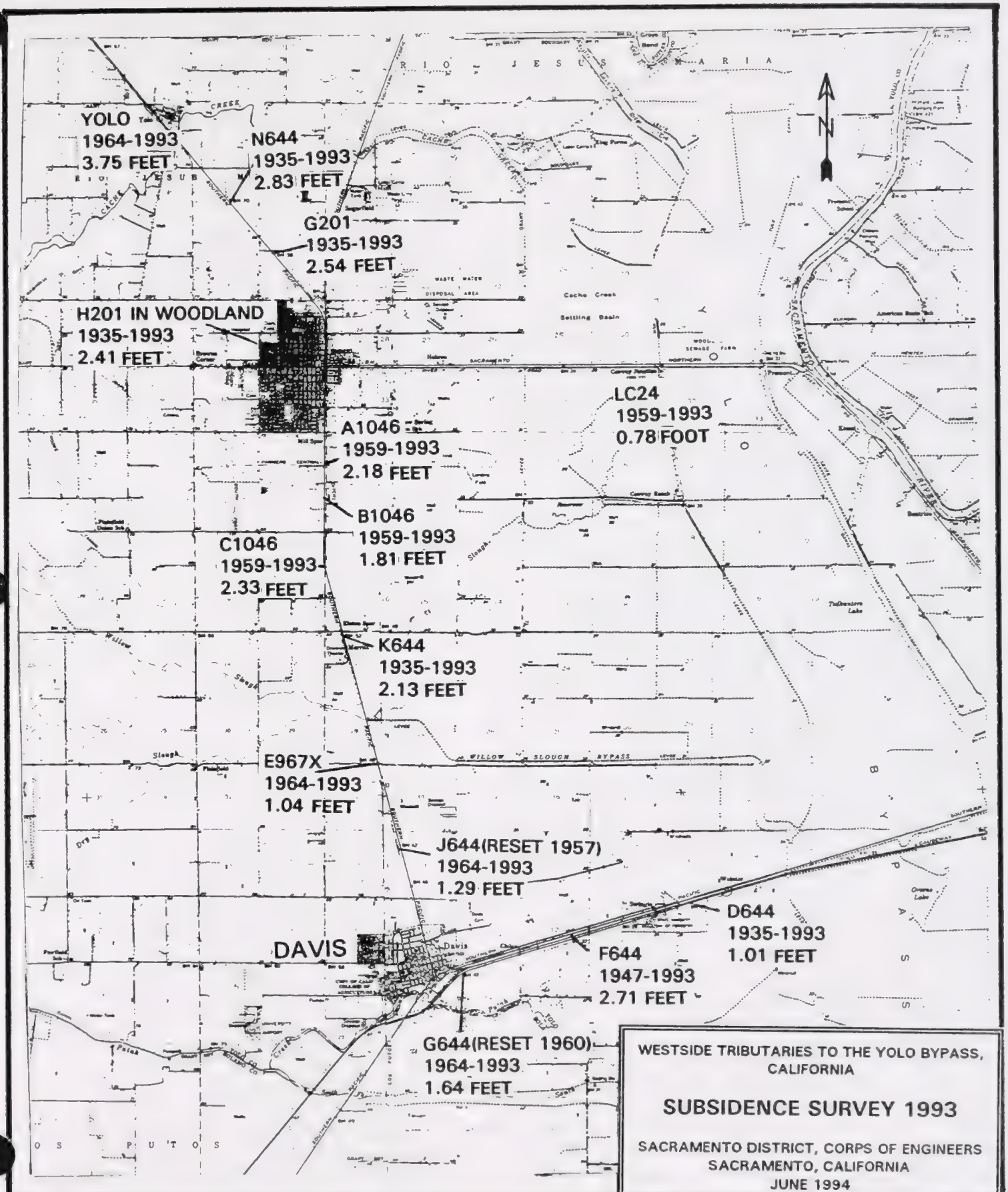
0 5 10 15 20

WESTSIDE TRIBUTARIES TO THE YOLO BYPAS
CALIFORNIA

FLOOD CONTROL MEASUR
ALONG CACHE CREEK

SACRAMENTO DISTRICT, CORPS OF ENGINEER
SACRAMENTO, CALIFORNIA
JUNE 1994

Plate 6

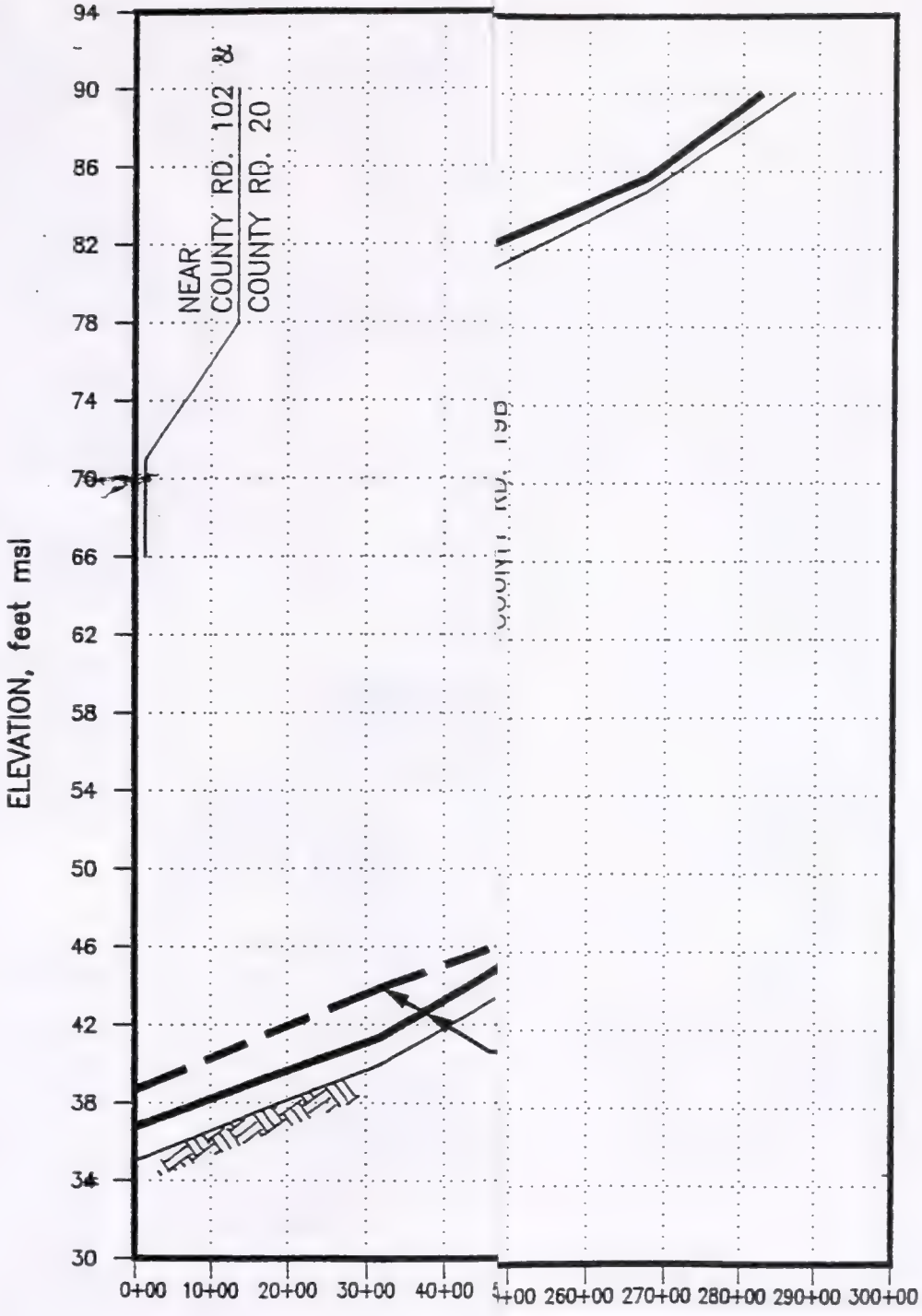


WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

SUBSIDENCE SURVEY 1993

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 7



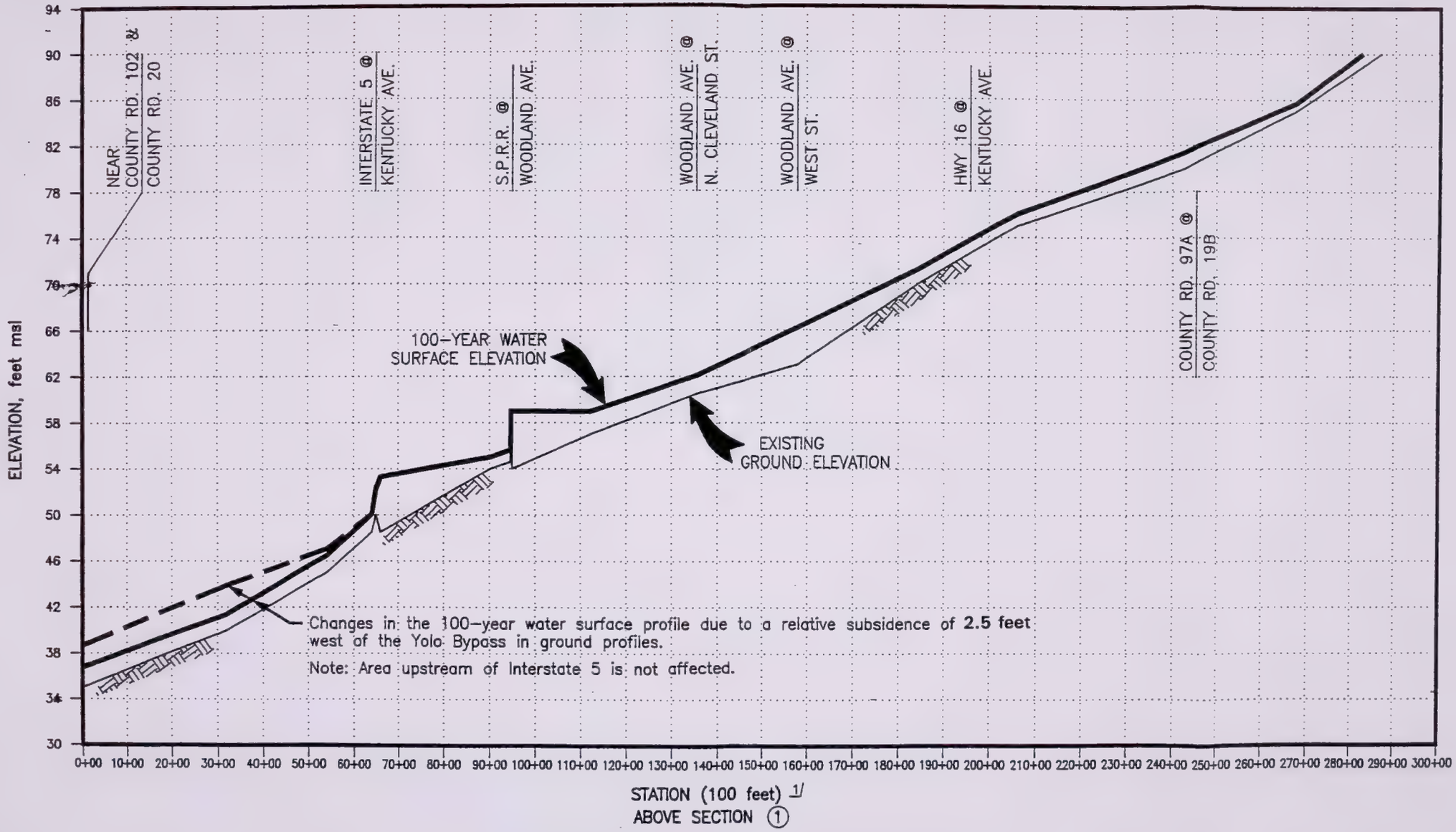
1/ Stationing is based u

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

WOODLAND FLOOD PLAIN PROFILE 1980

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 8


ELEVATION, feet msl
94
90
86
82
78
74
70
66
62
58
54
50
46
42
38
34
30
NEAR COUNTY RD. 102 & COUNTY RD. 20
INTERSTATE 5 @ KENTUCKY AVE.
S.P.R.R. @ WOODLAND AVE.
WOODLAND AVE. @ N. CLEVELAND ST.
WOODLAND AVE. @ WEST ST.
HWY 16 @ KENTUCKY AVE.
COUNTY RD. 97A @ COUNTY RD. 19B
100-YEAR WATER SURFACE ELEVATION
EXISTING GROUND ELEVATION
Changes in the 100-year water surface profile due to a relative subsidence of 2.5 feet west of the Yolo Bypass in ground profiles.
Note: Area upstream of Interstate 5 is not affected.
0+00 10+00 20+00 30+00 40+00 50+00 60+00 70+00 80+00 90+00 100+00 110+00 120+00 130+00 140+00 150+00 160+00 170+00 180+00 190+00 200+00 210+00 220+00 230+00 240+00 250+00 260+00 270+00 280+00 290+00 300+00
STATION (100 feet) 1/
ABOVE SECTION (1)

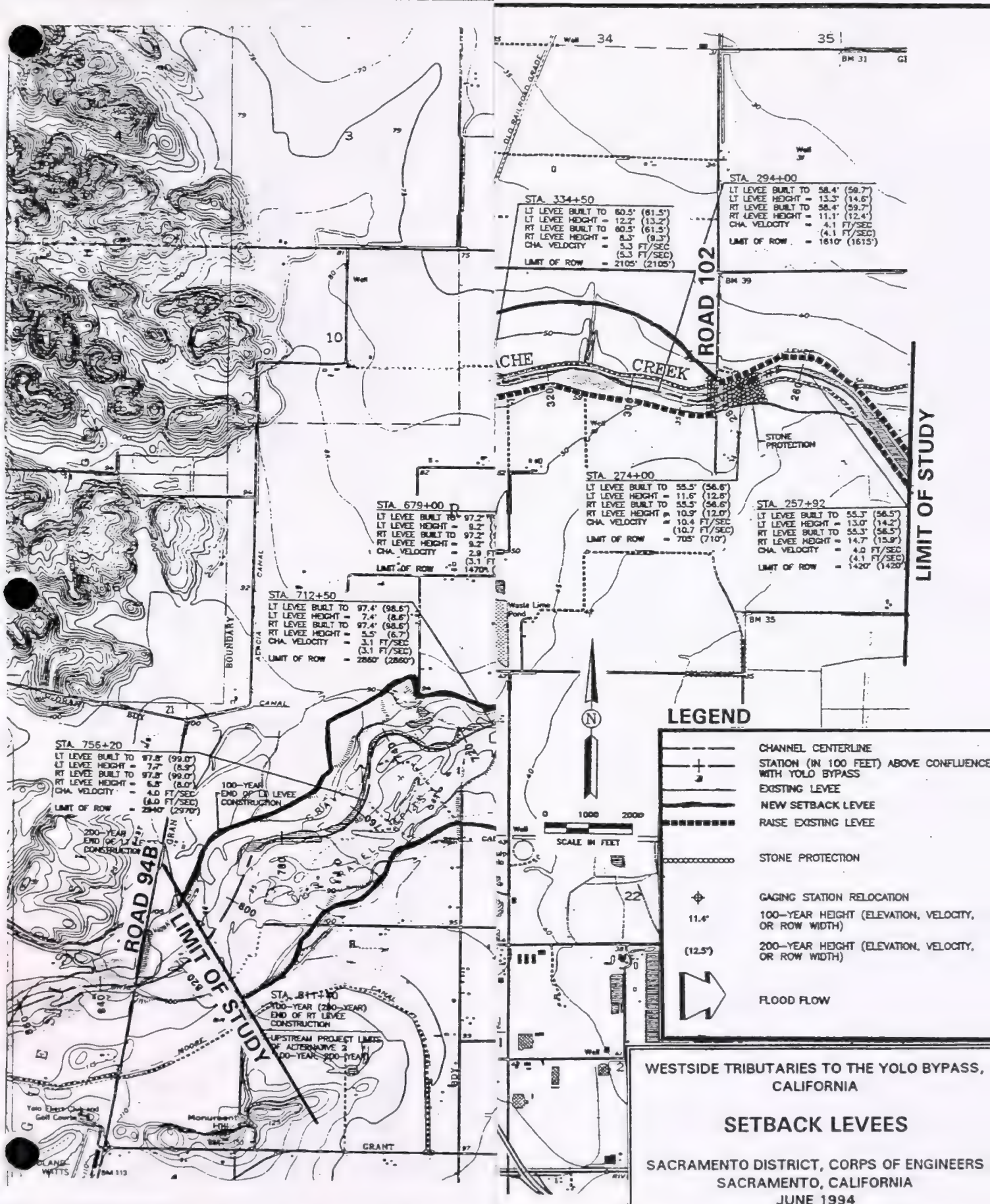
1/ Stationing is based upon centerline distances along Woodland floodplain.

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

WOODLAND FLOOD PLAIN PROFILE 1980

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 8

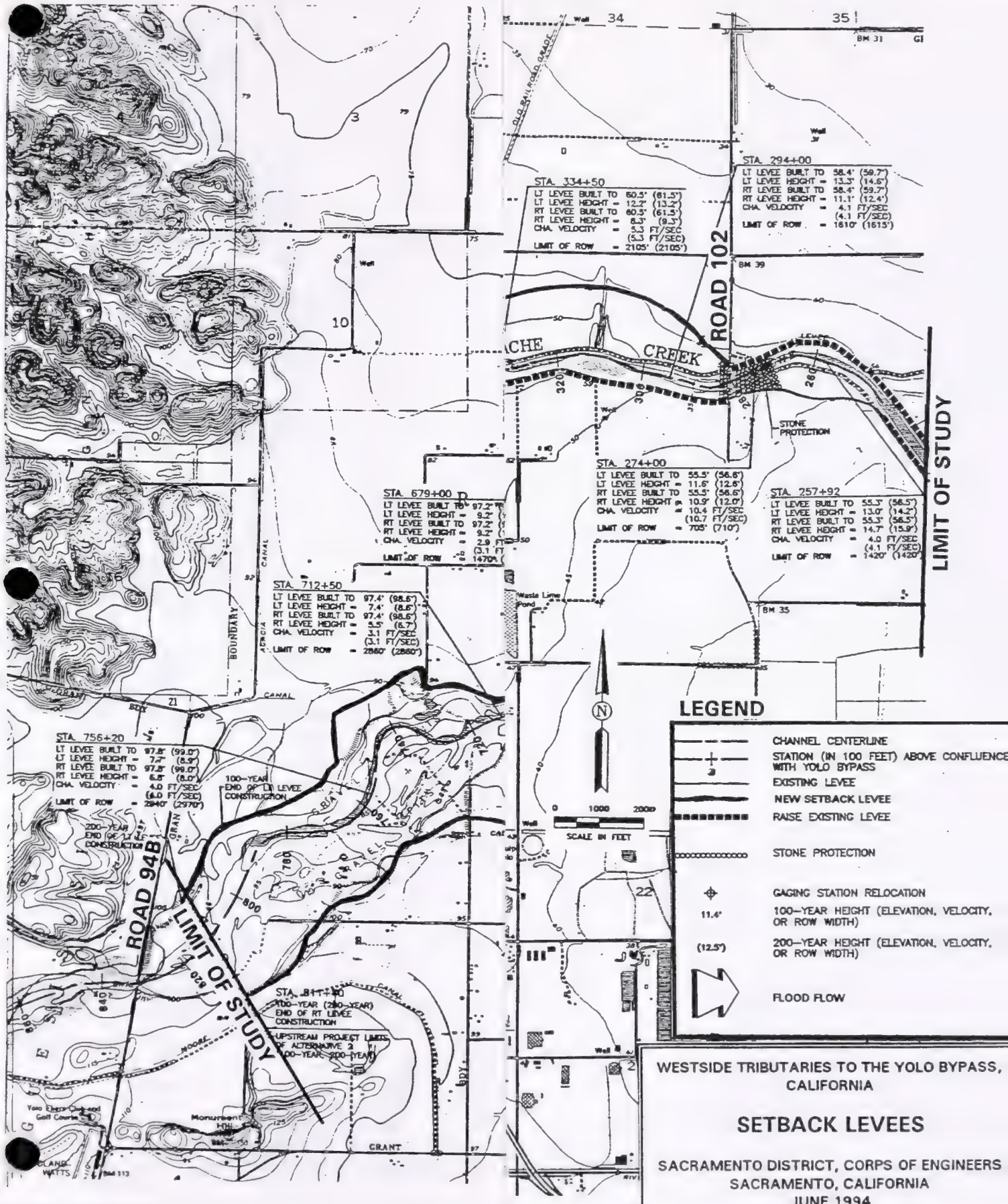

STA. 334+50
LT LEVEE BUILT TO 60.5' (61.5')
LT LEVEE HEIGHT = 12.2' (13.2')
RT LEVEE BUILT TO 60.5' (61.5')
RT LEVEE HEIGHT = 8.3' (9.3')
CHA. VELOCITY = 5.3 FT/SEC (5.3 FT/SEC)
LIMIT OF ROW = 2105' (2105')
STA. 294+00
LT LEVEE BUILT TO 58.4' (59.7')
LT LEVEE HEIGHT = 13.3' (14.6')
RT LEVEE BUILT TO 58.4' (59.7')
RT LEVEE HEIGHT = 11.1' (12.4')
CHA. VELOCITY = 4.1 FT/SEC (4.1 FT/SEC)
LIMIT OF ROW = 1610' (1615')
STA. 679+00
LT LEVEE BUILT TO 97.2'
LT LEVEE HEIGHT = 9.2'
RT LEVEE BUILT TO 97.2'
RT LEVEE HEIGHT = 9.2'
CHA. VELOCITY = 2.9 FT (3.1 FT
LIMIT OF ROW = 1470'
STA. 712+50
LT LEVEE BUILT TO 97.4' (98.6')
LT LEVEE HEIGHT = 7.4' (8.6')
RT LEVEE BUILT TO 97.4' (98.6')
RT LEVEE HEIGHT = 5.5' (6.7')
CHA. VELOCITY = 3.1 FT/SEC (3.1 FT/SEC)
LIMIT OF ROW = 2860' (2860')
STA. 274+00
LT LEVEE BUILT TO 55.5' (56.6')
LT LEVEE HEIGHT = 11.6' (12.8')
RT LEVEE BUILT TO 55.5' (56.6')
RT LEVEE HEIGHT = 10.9' (12.0')
CHA. VELOCITY = 10.4 FT/SEC (10.7 FT/SEC)
LIMIT OF ROW = 705' (710')
STA. 257+92
LT LEVEE BUILT TO 55.3' (56.5')
LT LEVEE HEIGHT = 13.0' (14.2')
RT LEVEE BUILT TO 55.3' (56.5')
RT LEVEE HEIGHT = 14.7' (15.9')
CHA. VELOCITY = 4.0 FT/SEC (4.1 FT/SEC)
LIMIT OF ROW = 1420' (1420')
STA. 756+20
LT LEVEE BUILT TO 97.8' (99.0')
LT LEVEE HEIGHT = 7.7' (8.9')
RT LEVEE BUILT TO 97.8' (99.0')
RT LEVEE HEIGHT = 6.8' (8.0')
CHA. VELOCITY = 4.0 FT/SEC (4.0 FT/SEC)
LIMIT OF ROW = 2940' (2970')
STA. 811+40
100-YEAR (200-YEAR) END OF RT LEVEE CONSTRUCTION
UPSTREAM PROJECT LIMITS OF ALTERNATIVE 2 100-YEAR, 200-(YEAR)
100-YEAR END OF LT LEVEE CONSTRUCTION
200-YEAR END OF LT LEVEE CONSTRUCTION
ROAD 94B
ROAD 102
LIMIT OF STUDY
CACHE CREEK
STONE PROTECTION
BOUNDARY
CANAL
Waste Lime Pond
BM 31
BM 35
BM 39
GRANT
SCALE IN FEET
0 1000 2000
LEGEND
CHANNEL CENTERLINE
STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
EXISTING LEVEE
NEW SETBACK LEVEE
RAISE EXISTING LEVEE
STONE PROTECTION
GAGING STATION RELOCATION
11.4' 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
(12.5') 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
FLOOD FLOW

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

SETBACK LEVEES

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 9

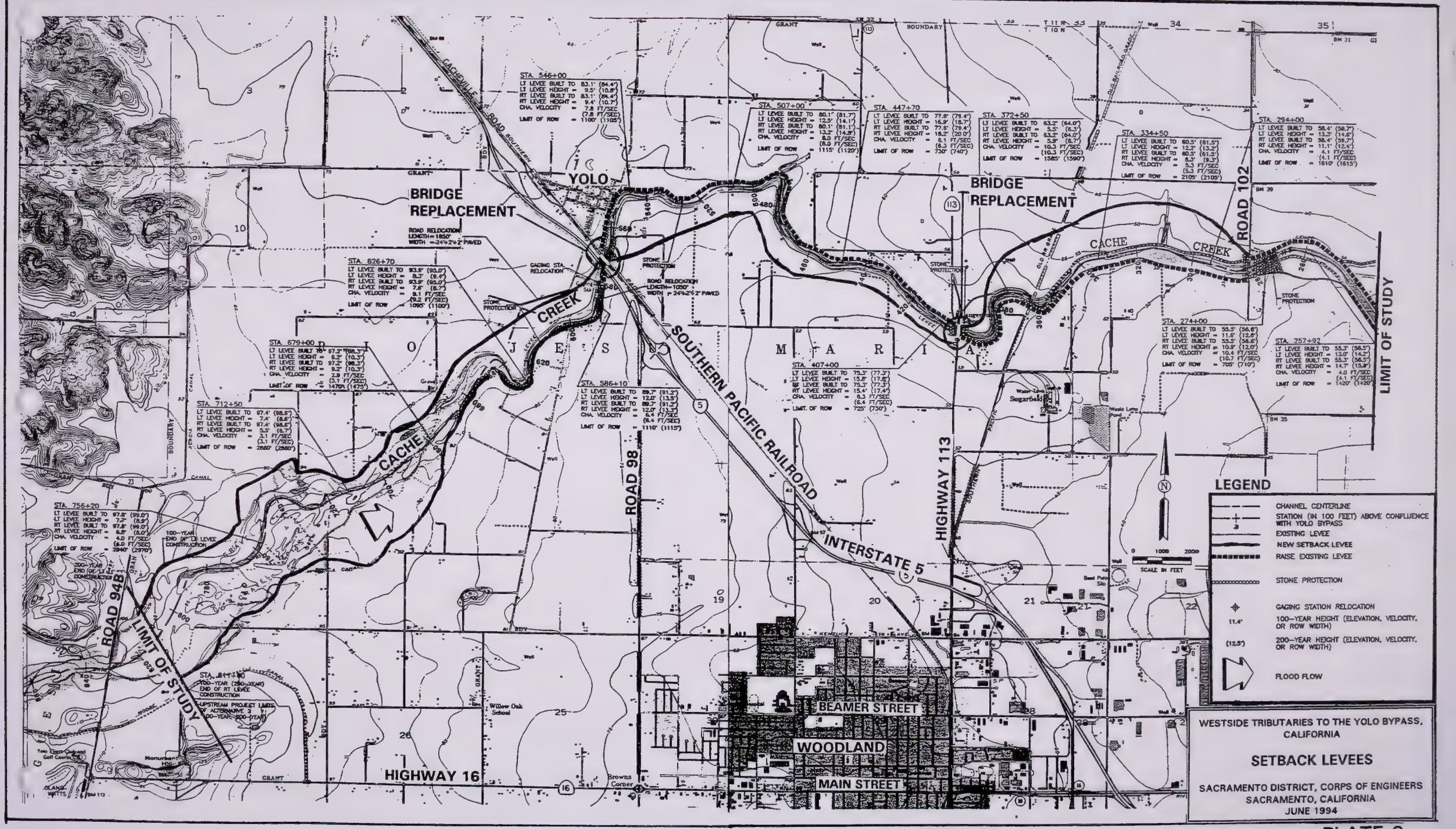

STA. 334+50
LT LEVEE BUILT TO 60.5' (61.5')
LT LEVEE HEIGHT = 12.2' (13.2')
RT LEVEE BUILT TO 60.5' (61.5')
RT LEVEE HEIGHT = 8.3' (9.3')
CHA. VELOCITY = 5.3 FT/SEC (5.3 FT/SEC)
LIMIT OF ROW = 2105' (2105')
STA. 294+00
LT LEVEE BUILT TO 58.4' (59.7')
LT LEVEE HEIGHT = 13.3' (14.6')
RT LEVEE BUILT TO 58.4' (59.7')
RT LEVEE HEIGHT = 11.1' (12.4')
CHA. VELOCITY = 4.1 FT/SEC (4.1 FT/SEC)
LIMIT OF ROW = 1610' (1615')
STA. 679+00
LT LEVEE BUILT TO 97.2'
LT LEVEE HEIGHT = 9.2'
RT LEVEE BUILT TO 97.2'
RT LEVEE HEIGHT = 9.2'
CHA. VELOCITY = 2.9 FT (3.1 FT)
LIMIT OF ROW = 1470'
STA. 712+50
LT LEVEE BUILT TO 97.4' (98.6')
LT LEVEE HEIGHT = 7.4' (8.6')
RT LEVEE BUILT TO 97.4' (98.6')
RT LEVEE HEIGHT = 5.5' (6.7')
CHA. VELOCITY = 3.1 FT/SEC (3.1 FT/SEC)
LIMIT OF ROW = 2860' (2860')
STA. 274+00
LT LEVEE BUILT TO 55.5' (56.6')
LT LEVEE HEIGHT = 11.6' (12.6')
RT LEVEE BUILT TO 55.5' (56.6')
RT LEVEE HEIGHT = 10.9' (12.0')
CHA. VELOCITY = 10.4 FT/SEC (10.7 FT/SEC)
LIMIT OF ROW = 705' (710')
STA. 257+92
LT LEVEE BUILT TO 55.3' (56.5')
LT LEVEE HEIGHT = 13.0' (14.2')
RT LEVEE BUILT TO 55.3' (56.5')
RT LEVEE HEIGHT = 14.7' (15.9')
CHA. VELOCITY = 4.0 FT/SEC (4.1 FT/SEC)
LIMIT OF ROW = 1420' (1420')
STA. 756+20
LT LEVEE BUILT TO 97.8' (99.0')
LT LEVEE HEIGHT = 7.7' (8.9')
RT LEVEE BUILT TO 97.8' (99.0')
RT LEVEE HEIGHT = 6.8' (8.0')
CHA. VELOCITY = 4.0 FT/SEC (4.0 FT/SEC)
LIMIT OF ROW = 2940' (2970')
STA. 811+40
100-YEAR (200-YEAR) END OF RT LEVEE CONSTRUCTION
UPSTREAM PROJECT LIMITS OF ALTERNATIVE 2 (100-YEAR, 200-YEAR)
100-YEAR END OF LT LEVEE CONSTRUCTION
200-YEAR END OF LT LEVEE CONSTRUCTION
ROAD 102
ROAD 94B
LIMIT OF STUDY
LIMIT OF STUDY
CACHE CREEK
STONE PROTECTION
Waste Lime Pond
Yolo Bypass
Monument Hill
Yolo Fliers Club and Golf Course
BOUNDARY
CANAL
MOORE
GRANT
BLAND
WATTS
BM 31
BM 39
BM 35
SCALE IN FEET
0
1000
2000
LEGEND
CHANNEL CENTERLINE
STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
EXISTING LEVEE
NEW SETBACK LEVEE
RAISE EXISTING LEVEE
STONE PROTECTION
GAGING STATION RELOCATION
11.4'
100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
(12.5')
200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
FLOOD FLOW

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

SETBACK LEVEES

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 9

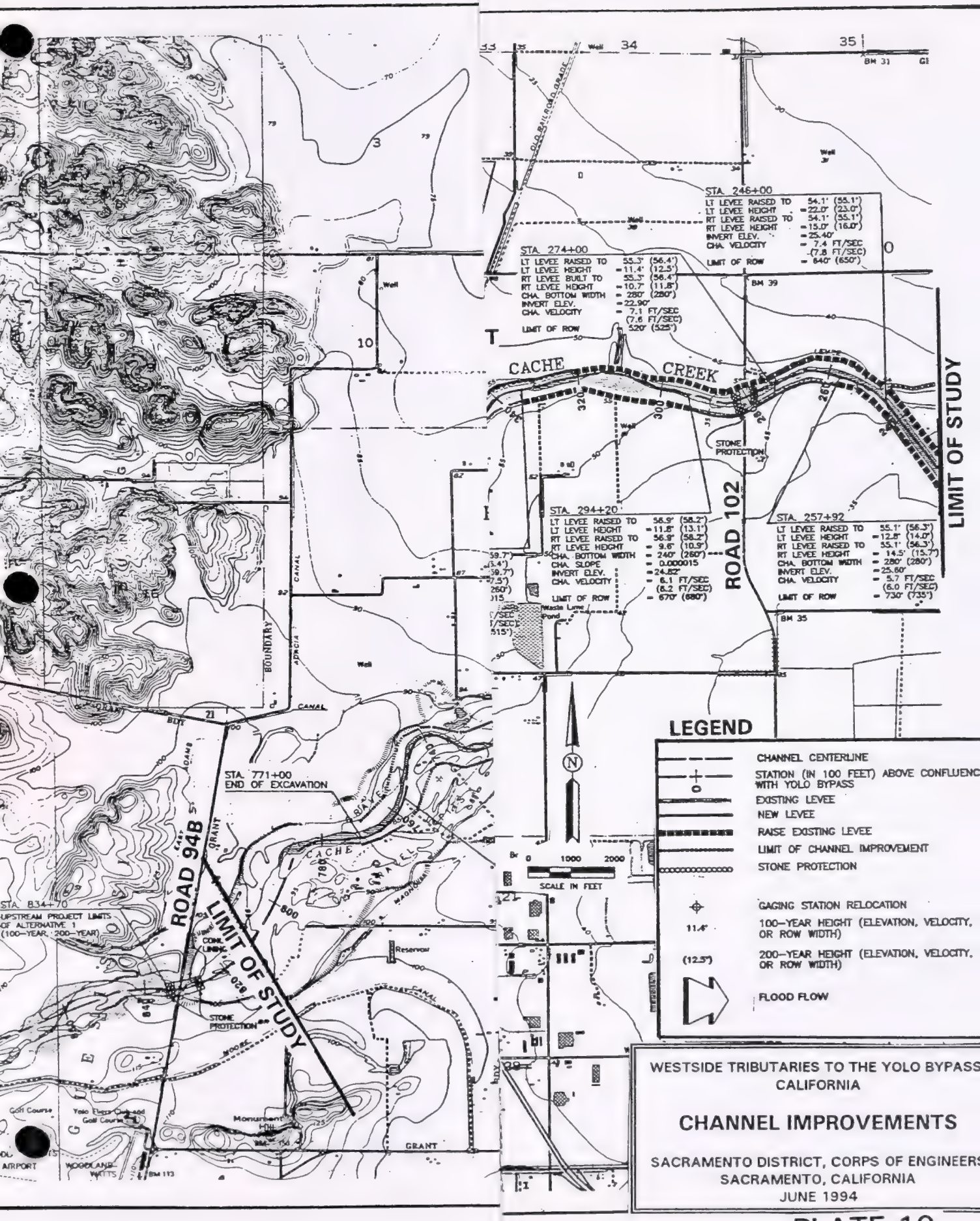


WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

SETBACK LEVEES

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 9


STA. 246+00
LT LEVEE RAISED TO 54.1' (55.1')
LT LEVEE HEIGHT = 22.0' (23.0')
RT LEVEE RAISED TO 54.1' (55.1')
RT LEVEE HEIGHT = 15.0' (16.0')
INVERT ELEV. = 25.40'
CHA. VELOCITY = 7.4 FT/SEC (7.8 FT/SEC)
LIMIT OF ROW = 840' (650')
STA. 274+00
LT LEVEE RAISED TO 55.3' (56.4')
LT LEVEE HEIGHT = 11.4' (12.5')
RT LEVEE BUILT TO 55.3' (56.4')
RT LEVEE HEIGHT = 10.7' (11.8')
CHA. BOTTOM WIDTH = 280' (280')
INVERT ELEV. = 22.90'
CHA. VELOCITY = 7.1 FT/SEC (7.6 FT/SEC)
LIMIT OF ROW 520' (525')
CACHE CREEK
STONE PROTECTION
LIMIT OF STUDY
ROAD 102
STA. 294+20
LT LEVEE RAISED TO 56.9' (58.2')
LT LEVEE HEIGHT = 11.8' (13.1')
RT LEVEE RAISED TO 56.9' (58.2')
RT LEVEE HEIGHT = 9.6' (10.9')
CHA. BOTTOM WIDTH = 240' (260')
CHA. SLOPE = 0.000015
INVERT ELEV. = 24.82'
CHA. VELOCITY = 6.1 FT/SEC (6.2 FT/SEC)
LIMIT OF ROW = 670' (680')
STA. 257+92
LT LEVEE RAISED TO 55.1' (56.3')
LT LEVEE HEIGHT = 12.8' (14.0')
RT LEVEE RAISED TO 55.1' (56.3')
RT LEVEE HEIGHT = 14.5' (15.7')
CHA. BOTTOM WIDTH = 280' (280')
INVERT ELEV. = 25.60'
CHA. VELOCITY = 5.7 FT/SEC (6.0 FT/SEC)
LIMIT OF ROW = 730' (735')
STA. 771+00
END OF EXCAVATION
ROAD 94B
LIMIT OF STUDY
STA. 834+70
UPSTREAM PROJECT LIMITS OF ALTERNATIVE 1 (100-YEAR, 200-YEAR)
BOUNDARY CANAL
CACHE CREEK
STONE PROTECTION
GRANT
WOODLAND
WATTS
Golf Course
Yolo Fliers Club and Golf Course
AIRPORT
Reservoir
Monument Hill
BM 113
BM 35
BM 39
BM 31
SCALE IN FEET
0 1000 2000
N

LEGEND

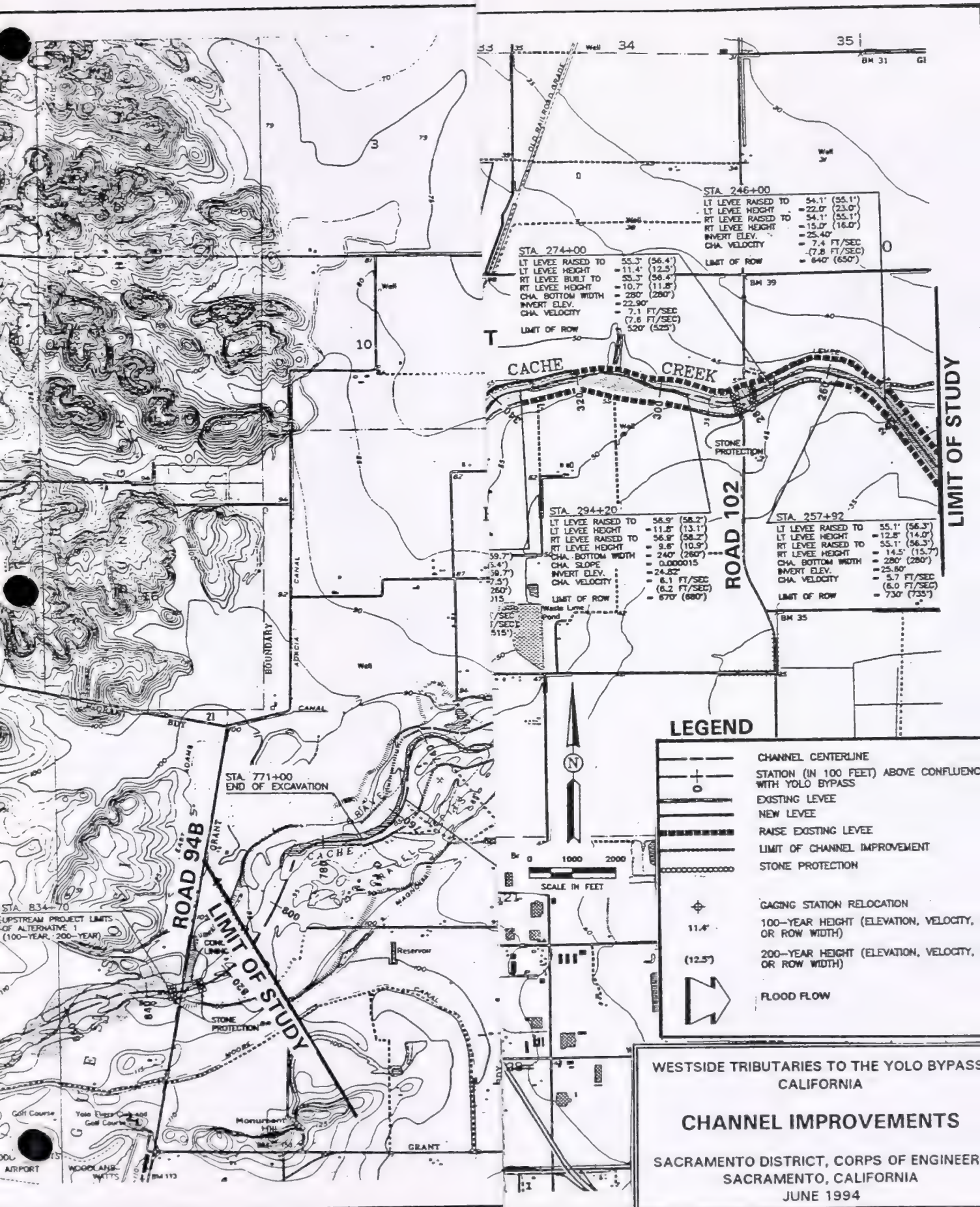
- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- GAGING STATION RELOCATION
- 11.4' — 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') — 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- FLOOD FLOW

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS
CALIFORNIA

CHANNEL IMPROVEMENTS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 10


STA. 246+00
LT LEVEE RAISED TO 54.1' (55.1')
LT LEVEE HEIGHT = 22.0' (23.0')
RT LEVEE RAISED TO 54.1' (55.1')
RT LEVEE HEIGHT = 15.0' (16.0')
INVERT ELEV. = 25.40'
CHA. VELOCITY = 7.4 FT/SEC (7.8 FT/SEC)
LIMIT OF ROW = 640' (650')
STA. 274+00
LT LEVEE RAISED TO 55.3' (56.4')
LT LEVEE HEIGHT = 11.4' (12.5')
RT LEVEE BUILT TO 55.3' (56.4')
RT LEVEE HEIGHT = 10.7' (11.8')
CHA. BOTTOM WIDTH = 280' (280')
INVERT ELEV. = 22.90'
CHA. VELOCITY = 7.1 FT/SEC (7.6 FT/SEC)
LIMIT OF ROW = 520' (525')
STA. 294+20
LT LEVEE RAISED TO 58.9' (58.2')
LT LEVEE HEIGHT = 11.8' (13.1')
RT LEVEE RAISED TO 56.9' (58.2')
RT LEVEE HEIGHT = 9.6' (10.9')
CHA. BOTTOM WIDTH = 240' (260')
CHA. SLOPE = 0.0000015
INVERT ELEV. = 24.82'
CHA. VELOCITY = 6.1 FT/SEC (6.2 FT/SEC)
LIMIT OF ROW = 670' (680')
STA. 257+92
LT LEVEE RAISED TO 55.1' (56.3')
LT LEVEE HEIGHT = 12.8' (14.0')
RT LEVEE RAISED TO 55.1' (56.3')
RT LEVEE HEIGHT = 14.5' (15.7')
CHA. BOTTOM WIDTH = 280' (280')
INVERT ELEV. = 25.60'
CHA. VELOCITY = 5.7 FT/SEC (6.0 FT/SEC)
LIMIT OF ROW = 730' (735')
CACHE CREEK
ROAD 102
ROAD 94B
LIMIT OF STUDY
STA. 771+00
END OF EXCAVATION
STA. 834+70
UPSTREAM PROJECT LIMITS
OF ALTERNATIVE 1
(100-YEAR, 200-YEAR)
STONE PROTECTION
Waste Lyne Pond
Reservoir
Golf Course
AIRPORT
WOODLAND
WATTS
GRANT
BOUNDARY
CANAL
SCALE IN FEET
0 1000 2000
LEGEND
CHANNEL CENTERLINE
STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
EXISTING LEVEE
NEW LEVEE
RAISE EXISTING LEVEE
LIMIT OF CHANNEL IMPROVEMENT
STONE PROTECTION
GAGING STATION RELOCATION
11.4' 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
(12.5') 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
FLOOD FLOW

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS
CALIFORNIA

CHANNEL IMPROVEMENTS

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 10

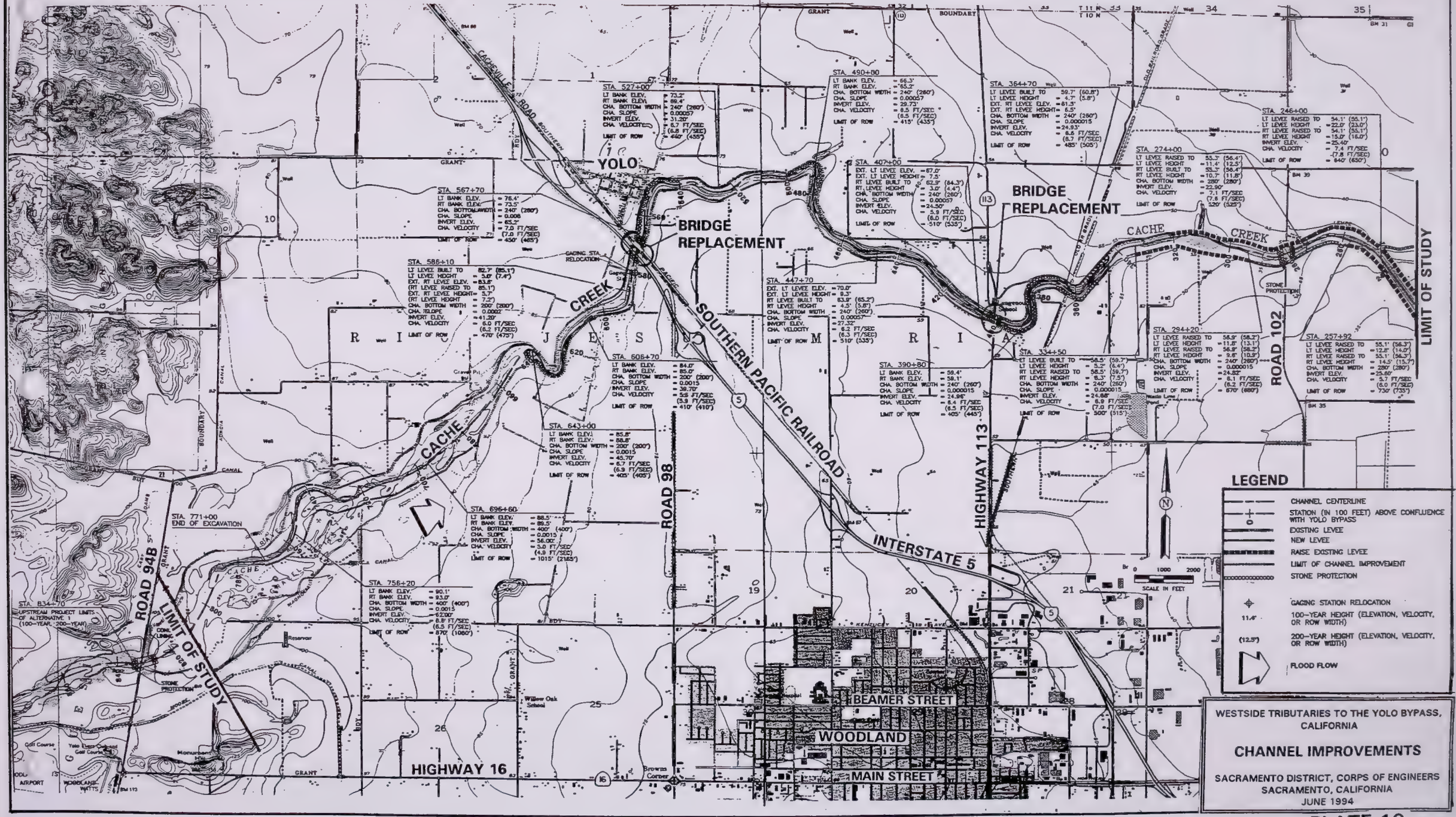
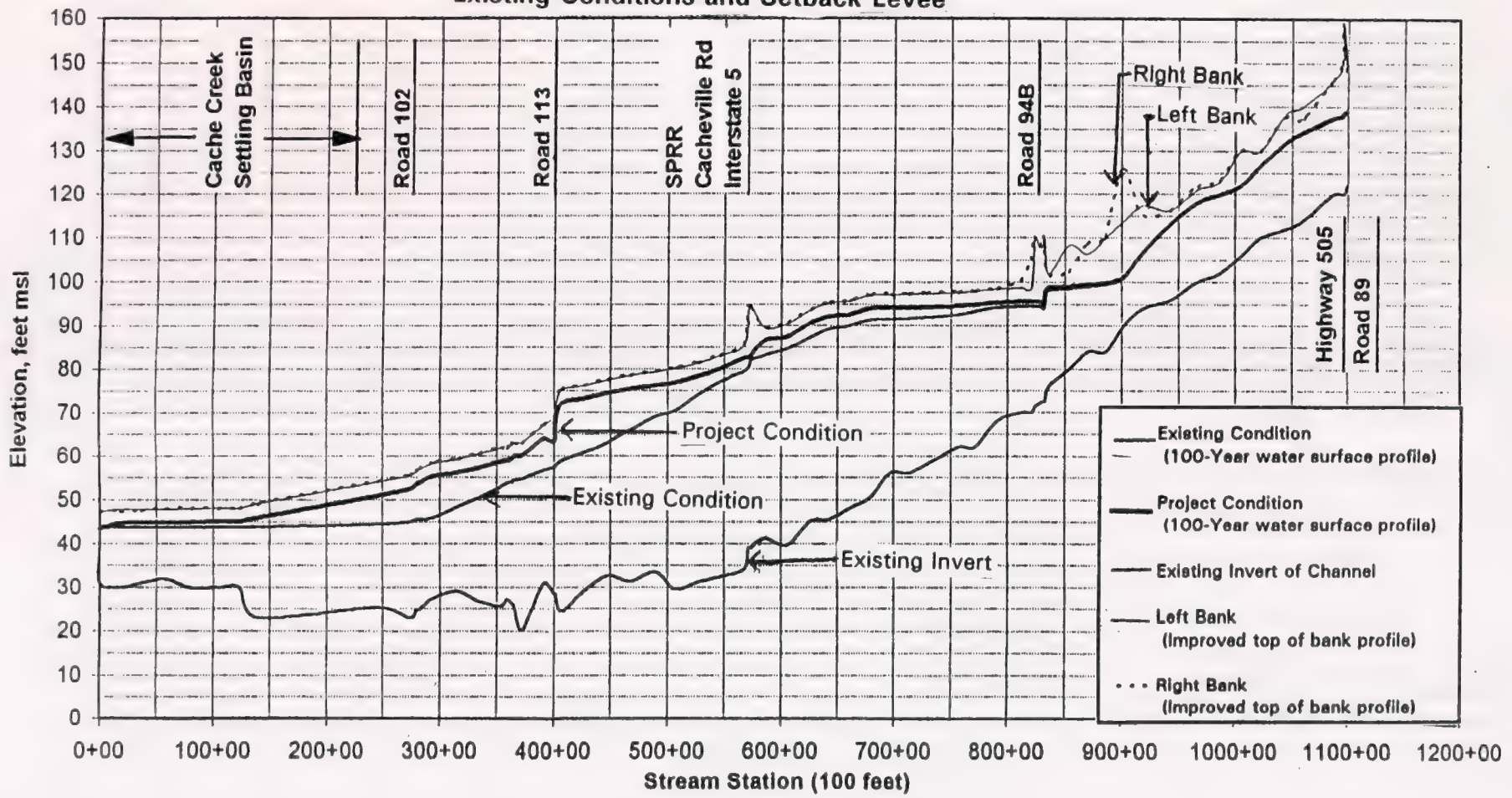

YOLO
BRIDGE REPLACEMENT
BRIDGE REPLACEMENT
CACHE CREEK
CACHE CREEK
SOUTHERN PACIFIC RAILROAD
INTERSTATE 5
HIGHWAY 113
ROAD 98
ROAD 94B
ROAD 102
HIGHWAY 16
LIMIT OF STUDY
LIMIT OF STUDY
BEAMER STREET
WOODLAND
MAIN STREET
CACHEVILLE ROAD SOUTHERN
GRANT
BOUNDARY
STONE PROTECTION
STONE PROTECTION
GAGING STA RELOCATION
STA 771+00
END OF EXCAVATION
STA 834+70
UPSTREAM PROJECT LIMITS OF ALTERNATIVE 1 (100-YEAR, 200-YEAR)
STA 527+00
LT BANK ELEV. = 73.2'
RT BANK ELEV. = 69.4'
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.00057
INVERT ELEV. = 31.20'
CHA. VELOCITY = 6.7 FT/SEC (6.8 FT/SEC)
LIMIT OF ROW = 440' (435')
STA 567+70
LT BANK ELEV. = 76.4'
RT BANK ELEV. = 73.5'
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.008
INVERT ELEV. = 65.2'
CHA. VELOCITY = 7.0 FT/SEC (7.0 FT/SEC)
LIMIT OF ROW = 450' (485')
STA 586+10
LT LEVEE BUILT TO = 82.7' (85.1')
LT LEVEE HEIGHT = 5.0' (7.4')
EXT. RT LEVEE ELEV. = 83.5'
(RT LEVEE RAISED TO = 85.1')
EXT. RT LEVEE HEIGHT = 5.7'
(RT LEVEE HEIGHT = 7.2')
CHA. BOTTOM WIDTH = 200' (200')
CHA. SLOPE = 0.0002
INVERT ELEV. = 41.20'
CHA. VELOCITY = 6.0 FT/SEC (6.2 FT/SEC)
LIMIT OF ROW = 470' (475')
STA 606+70
LT BANK ELEV. = 84.0'
RT BANK ELEV. = 85.0'
CHA. BOTTOM WIDTH = 200' (200')
CHA. SLOPE = 0.0015
INVERT ELEV. = 39.70'
CHA. VELOCITY = 5.5 FT/SEC (5.9 FT/SEC)
LIMIT OF ROW = 410' (410')
STA 643+00
LT BANK ELEV. = 85.8'
RT BANK ELEV. = 86.8'
CHA. BOTTOM WIDTH = 200' (200')
CHA. SLOPE = 0.0015
INVERT ELEV. = 45.70'
CHA. VELOCITY = 6.7 FT/SEC (6.9 FT/SEC)
LIMIT OF ROW = 405' (405')
STA 696+60
LT BANK ELEV. = 88.5'
RT BANK ELEV. = 89.5'
CHA. BOTTOM WIDTH = 400' (400')
CHA. SLOPE = 0.0015
INVERT ELEV. = 56.00'
CHA. VELOCITY = 5.0 FT/SEC (4.9 FT/SEC)
LIMIT OF ROW = 1015' (2165')
STA 756+20
LT BANK ELEV. = 90.1'
RT BANK ELEV. = 93.0'
CHA. BOTTOM WIDTH = 400' (400')
CHA. SLOPE = 0.0015
INVERT ELEV. = 62.00'
CHA. VELOCITY = 6.8 FT/SEC (6.5 FT/SEC)
LIMIT OF ROW = 870' (1080')
STA 447+70
EXT. LT LEVEE ELEV. = 70.0'
EXT. LT LEVEE HEIGHT = 8.3'
RT LEVEE BUILT TO = 83.5' (85.2')
RT LEVEE HEIGHT = 4.5' (5.8')
CHA. BOTTOM WIDTH = 240' (260')
CHA. SLOPE = 0.00057
INVERT ELEV. = 27.32'
CHA. VELOCITY = 6.2 FT/SEC (6.3 FT/SEC)
LIMIT OF ROW = 510' (535')
STA 407+00
EXT. LT LEVEE ELEV. = 67.0'
EXT. LT LEVEE HEIGHT = 7.5'
RT LEVEE BUILT TO = 82.3' (84.3')
RT LEVEE HEIGHT = 3.0' (4.4')
CHA. BOTTOM WIDTH = 240' (260')
CHA. SLOPE = 0.00057
INVERT ELEV. = 24.50'
CHA. VELOCITY = 5.9 FT/SEC (6.0 FT/SEC)
LIMIT OF ROW = 510' (535')
STA 490+80
LT BANK ELEV. = 66.3'
RT BANK ELEV. = 65.2'
CHA. BOTTOM WIDTH = 240' (260')
CHA. SLOPE = 0.00057
INVERT ELEV. = 29.73'
CHA. VELOCITY = 6.5 FT/SEC (6.5 FT/SEC)
LIMIT OF ROW = 415' (435')
STA 390+80
LT BANK ELEV. = 58.4'
RT BANK ELEV. = 58.1'
CHA. BOTTOM WIDTH = 240' (260')
CHA. SLOPE = 0.000015
INVERT ELEV. = 24.96'
CHA. VELOCITY = 6.4 FT/SEC (6.5 FT/SEC)
LIMIT OF ROW = 405' (445')
STA 364+70
LT LEVEE BUILT TO = 59.7' (60.8')
LT LEVEE HEIGHT = 6.7' (5.8')
EXT. RT LEVEE ELEV. = 61.5'
EXT. RT LEVEE HEIGHT = 6.5'
CHA. BOTTOM WIDTH = 240' (260')
CHA. SLOPE = 0.000015
INVERT ELEV. = 24.93'
CHA. VELOCITY = 6.5 FT/SEC (6.7 FT/SEC)
LIMIT OF ROW = 485' (505')
STA 334+50
LT LEVEE BUILT TO = 58.5' (59.7')
LT LEVEE HEIGHT = 5.2' (6.4')
RT LEVEE RAISED TO = 58.5' (59.7')
RT LEVEE HEIGHT = 6.3' (7.5')
CHA. BOTTOM WIDTH = 240' (260')
CHA. SLOPE = 0.000015
INVERT ELEV. = 24.85'
CHA. VELOCITY = 6.9 FT/SEC (7.0 FT/SEC)
LIMIT OF ROW = 500' (515')
STA 294+20
LT LEVEE RAISED TO = 58.9' (58.2')
LT LEVEE HEIGHT = 11.8' (13.1')
RT LEVEE RAISED TO = 58.9' (58.2')
RT LEVEE HEIGHT = 9.6' (10.9')
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.000015
INVERT ELEV. = 24.82'
CHA. VELOCITY = 6.1 FT/SEC (6.2 FT/SEC)
LIMIT OF ROW = 870' (880')
STA 274+00
LT LEVEE RAISED TO = 55.3' (56.4')
LT LEVEE HEIGHT = 11.4' (12.5')
RT LEVEE BUILT TO = 55.3' (56.4')
RT LEVEE HEIGHT = 10.7' (11.8')
CHA. BOTTOM WIDTH = 280' (280')
INVERT ELEV. = 22.90'
CHA. VELOCITY = 7.1 FT/SEC (7.5 FT/SEC)
LIMIT OF ROW = 520' (525')
STA 246+00
LT LEVEE RAISED TO = 54.1' (55.1')
LT LEVEE HEIGHT = 22.0' (23.0')
RT LEVEE RAISED TO = 54.1' (55.1')
RT LEVEE HEIGHT = 15.0' (16.0')
INVERT ELEV. = 25.40'
CHA. VELOCITY = 7.4 FT/SEC (7.8 FT/SEC)
LIMIT OF ROW = 840' (650')
STA 257+92
LT LEVEE RAISED TO = 55.1' (56.3')
LT LEVEE HEIGHT = 12.8' (14.0')
RT LEVEE RAISED TO = 55.1' (56.3')
RT LEVEE HEIGHT = 14.5' (15.7')
CHA. BOTTOM WIDTH = 280' (280')
INVERT ELEV. = 25.80'
CHA. VELOCITY = 5.7 FT/SEC (6.0 FT/SEC)
LIMIT OF ROW = 730' (735')
LEGEND
CHANNEL CENTERLINE
STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
EXISTING LEVEE
NEW LEVEE
RAISE EXISTING LEVEE
LIMIT OF CHANNEL IMPROVEMENT
STONE PROTECTION
GAGING STATION RELOCATION
100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
FLOOD FLOW
SCALE IN FEET
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA
CHANNEL IMPROVEMENTS
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 10



NOTE: EXISTING CONDITIONS REFLECT DECREASE IN 100-YEAR FLOOD FLOWS DUE TO OVERBANK LOSSES.

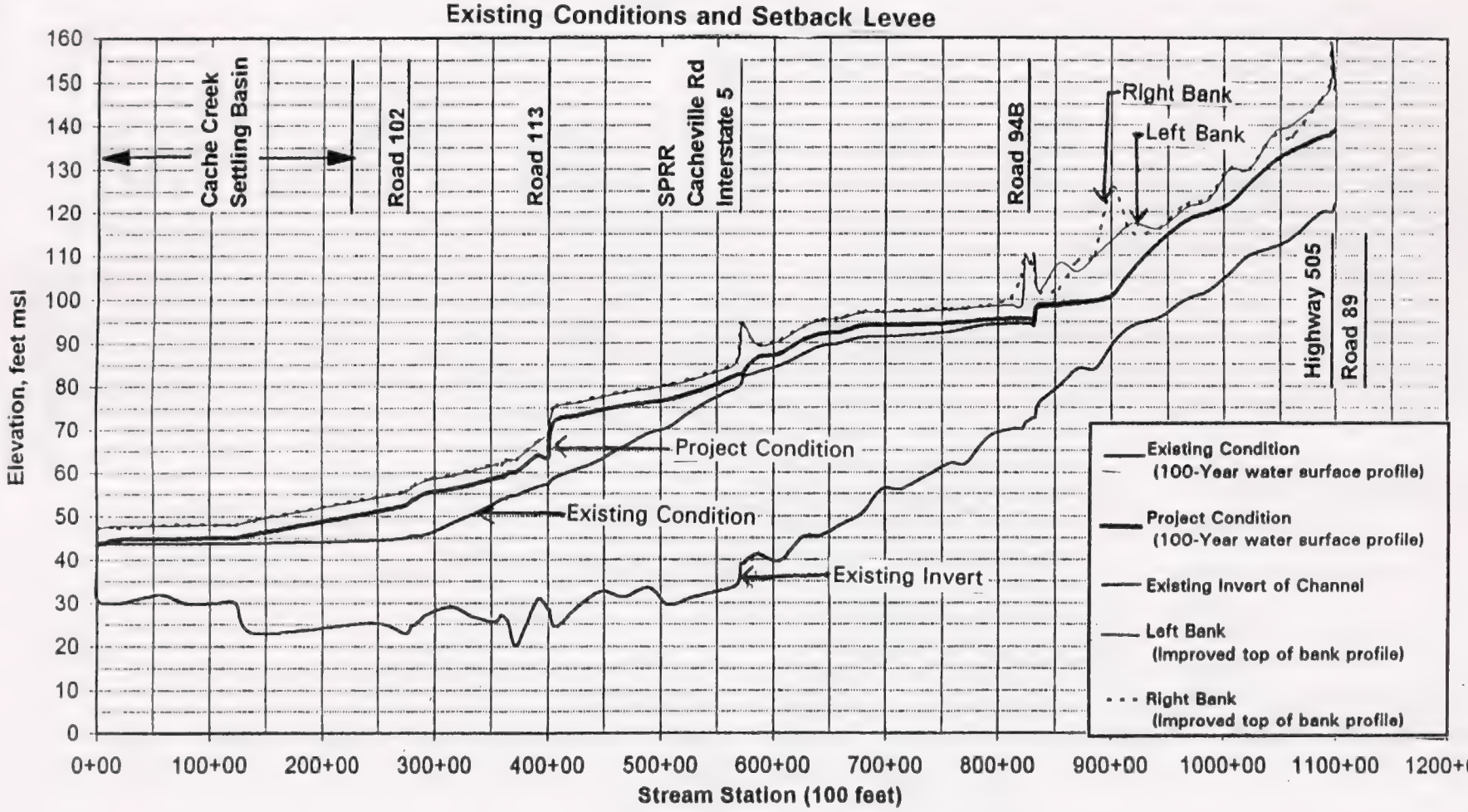
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

SETBACK LEVEE ALTERNATIVE

CACHE CREEK 100-YEAR WATER SURFACE PROFILES

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 11



NOTE: EXISTING CONDITIONS REFLECT DECREASE IN 100-YEAR FLOOD FLOWS DUE TO OVERBANK LOSSES.

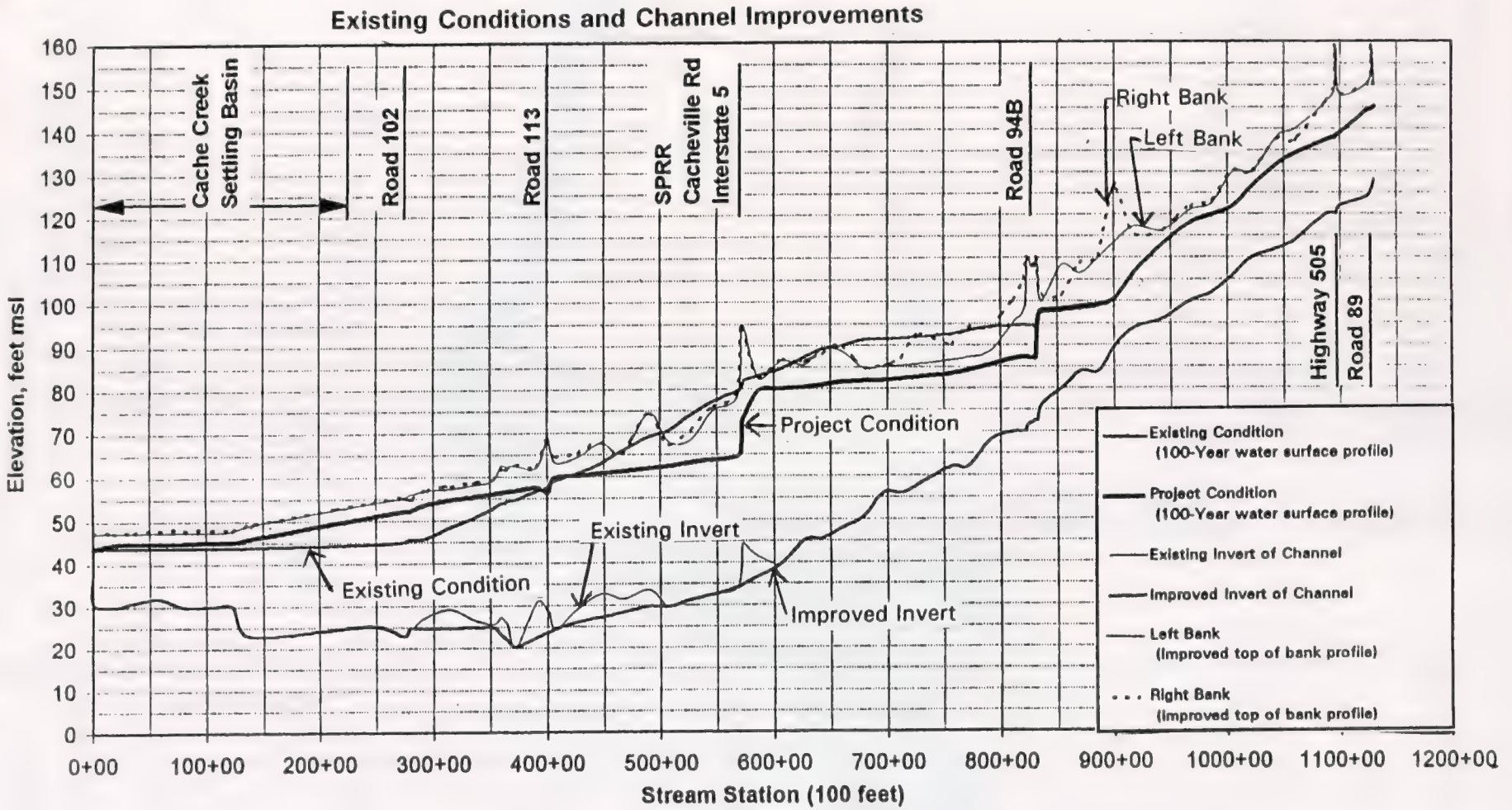
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

SETBACK LEVEE ALTERNATIVE

CACHE CREEK 100-YEAR WATER SURFACE PROFILES

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 11



NOTE: EXISTING CONDITIONS REFLECT DECREASE IN 100–YEAR FLOOD FLOWS DUE TO OVERBANK LOSSES.

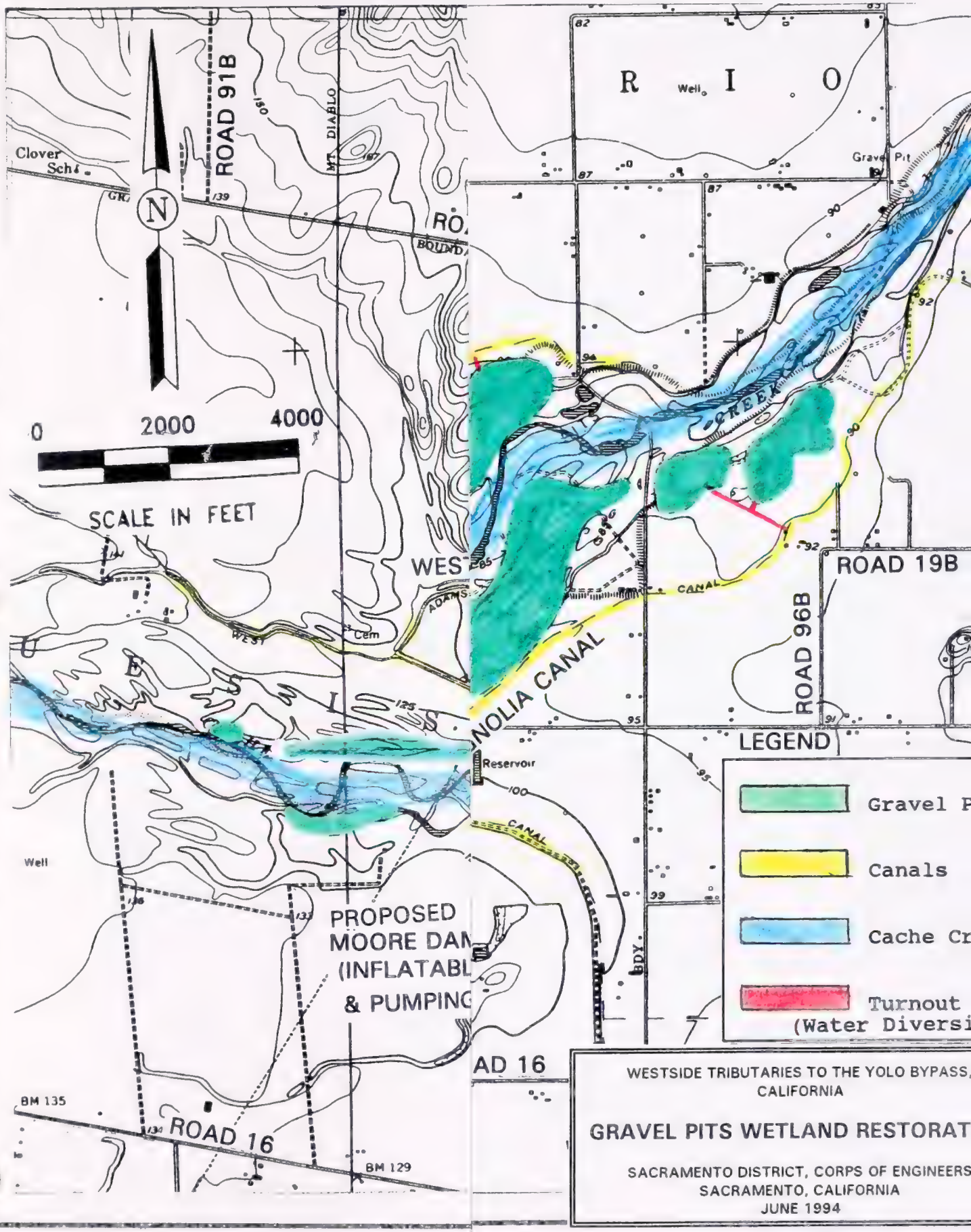
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

CHANNEL IMPROVEMENT ALTERNATIVE

CACHE CREEK 100-YEAR WATER SURFACE PROFILES

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 12

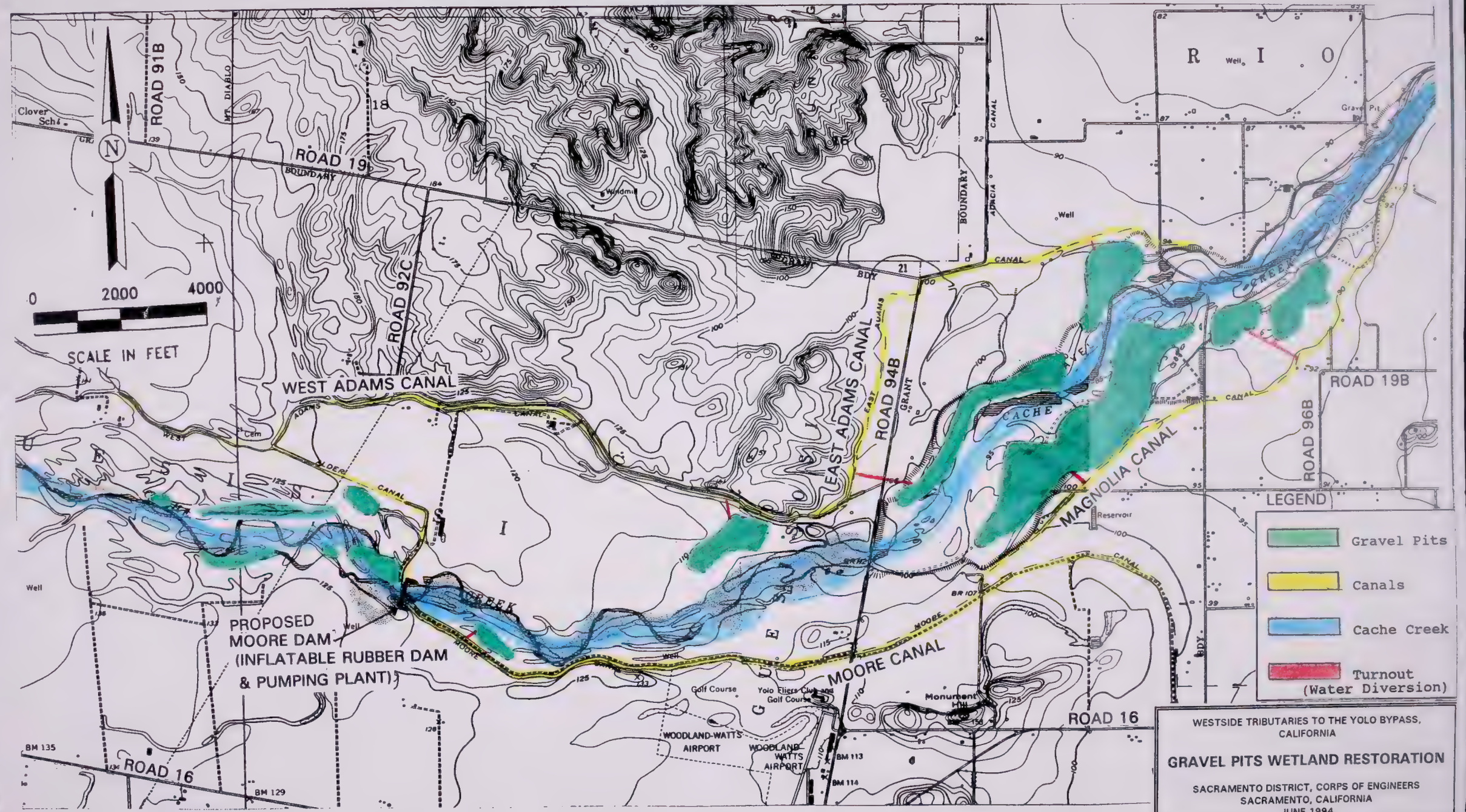


WESTSIDE TRIBUTARIES TO THE YOLO BYPASS,
CALIFORNIA

GRAVEL PITS WETLAND RESTORAT

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 13

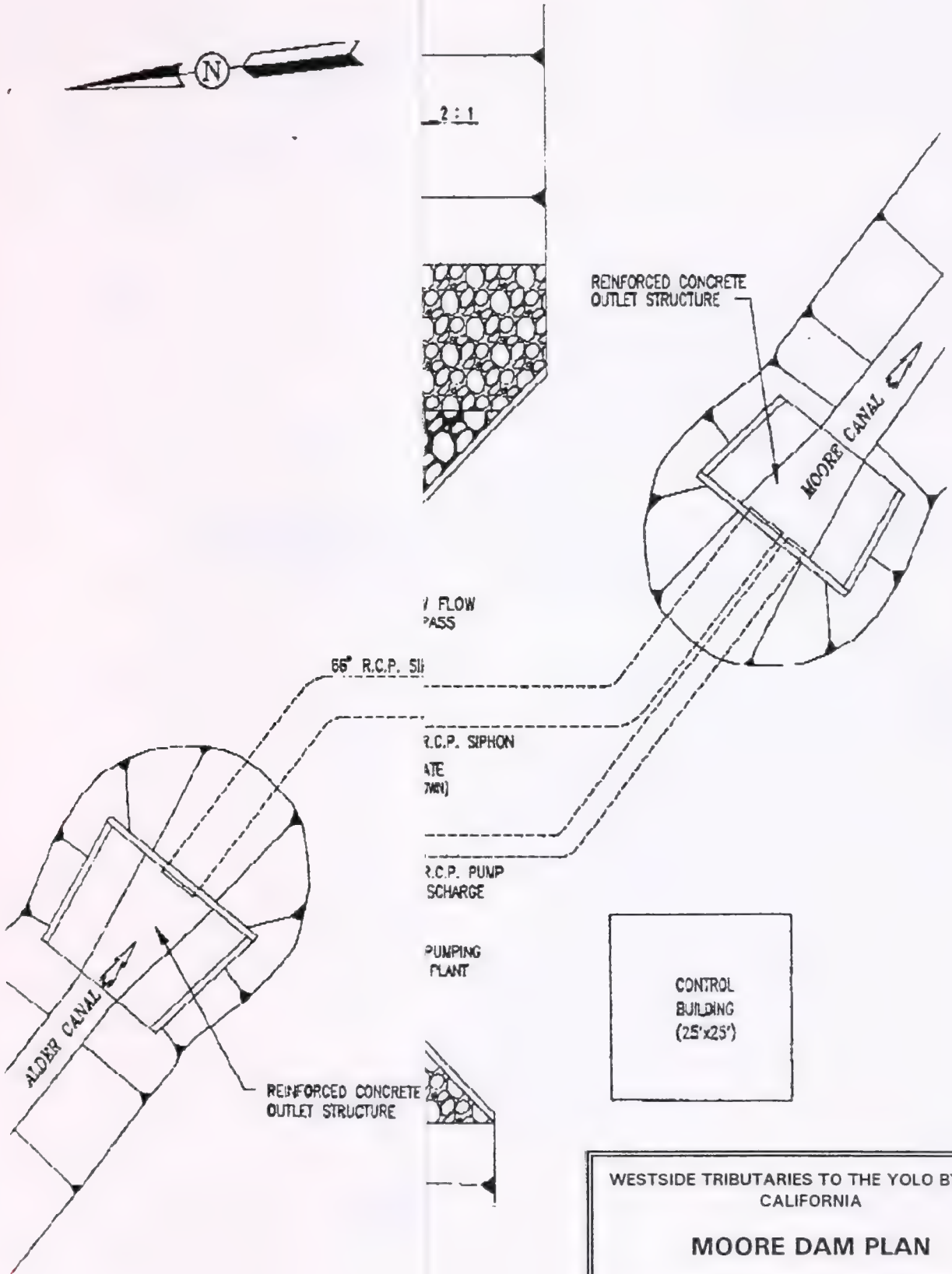


WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

GRAVEL PITS WETLAND RESTORATION

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 13

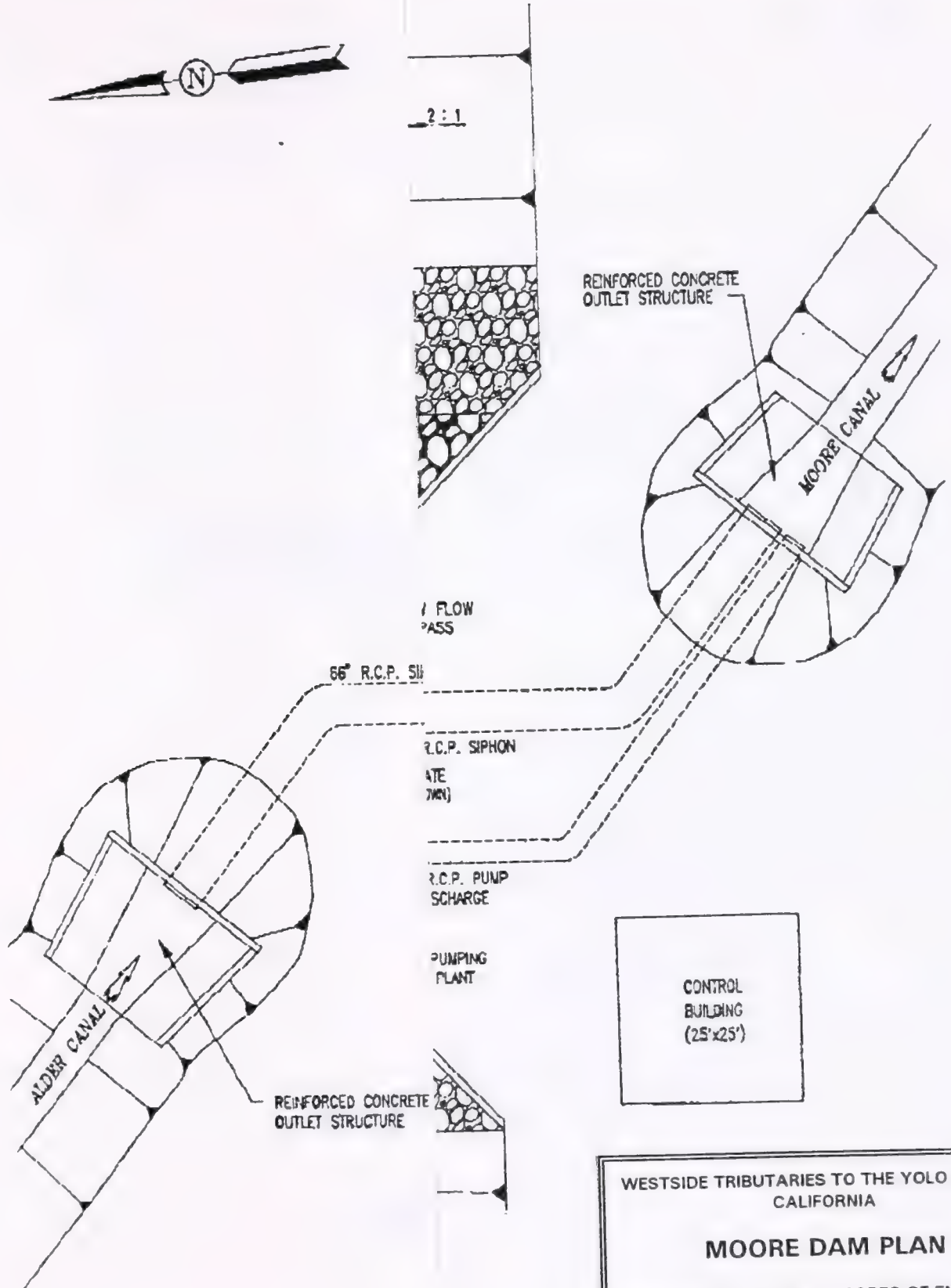


WESTSIDE TRIBUTARIES TO THE YOLO BYPASS
CALIFORNIA

MOORE DAM PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 14

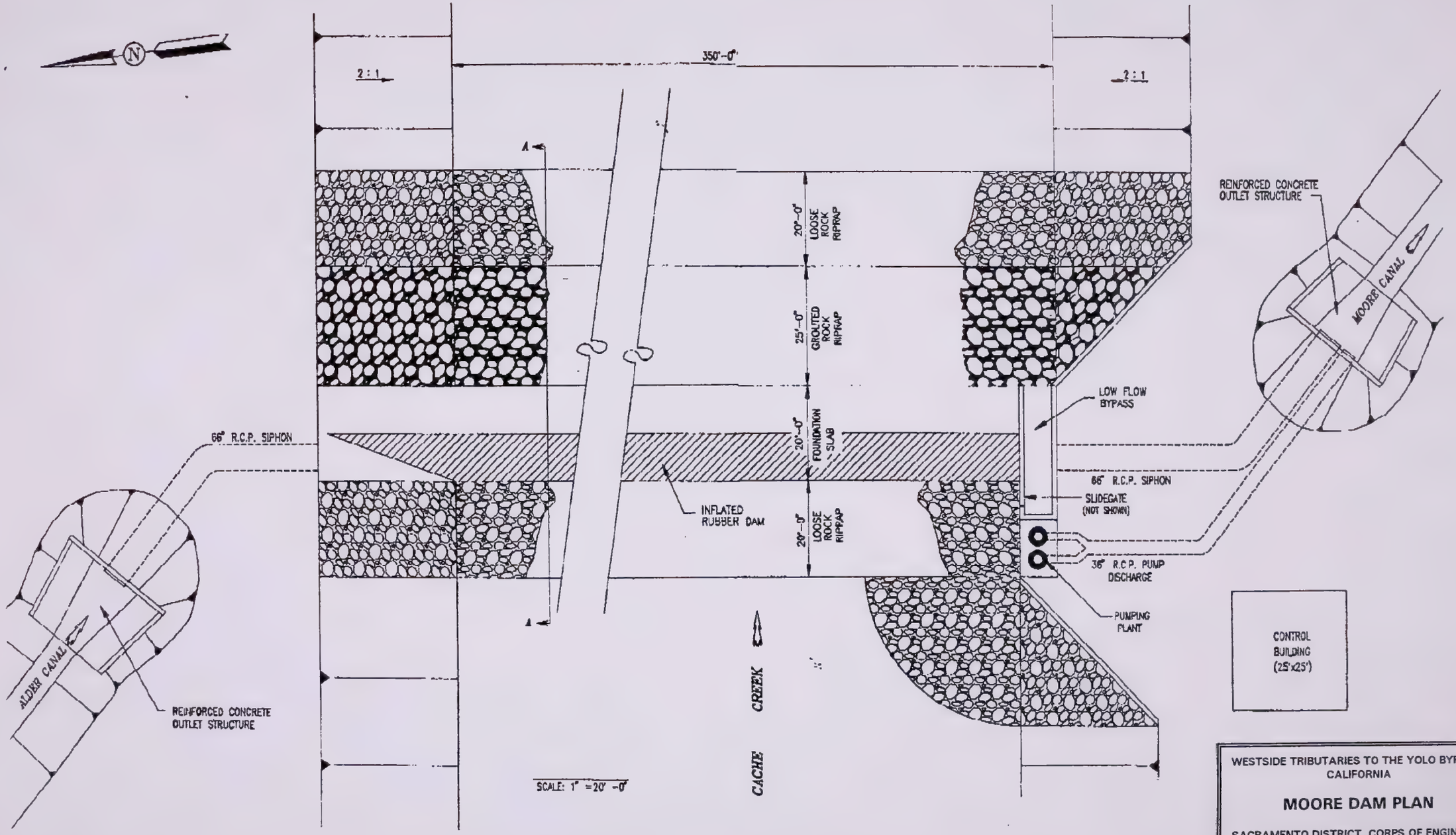


WESTSIDE TRIBUTARIES TO THE YOLO BYPAS
CALIFORNIA

MOORE DAM PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEE
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 14

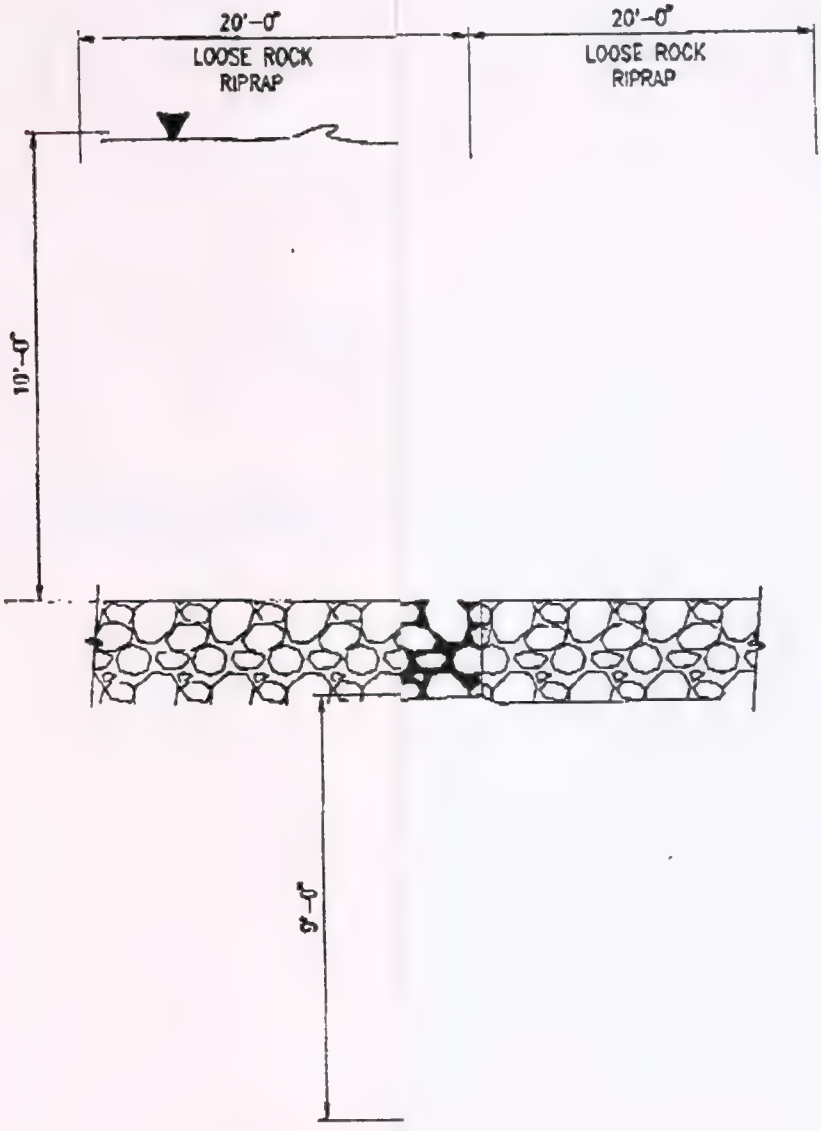


WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

MOORE DAM PLAN

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 14

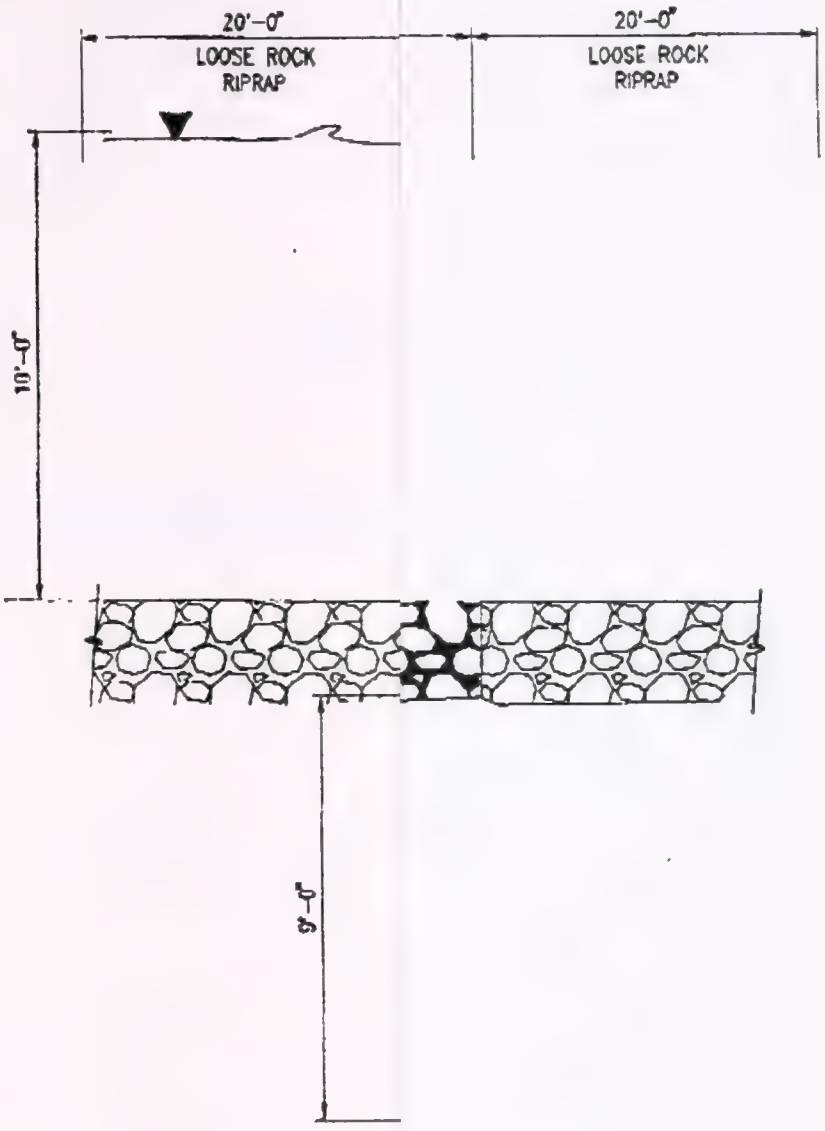


WESTSIDE TRIBUTARIES TO THE YOLO BYPASS
CALIFORNIA

MOORE DAM SECTION A-A

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 15

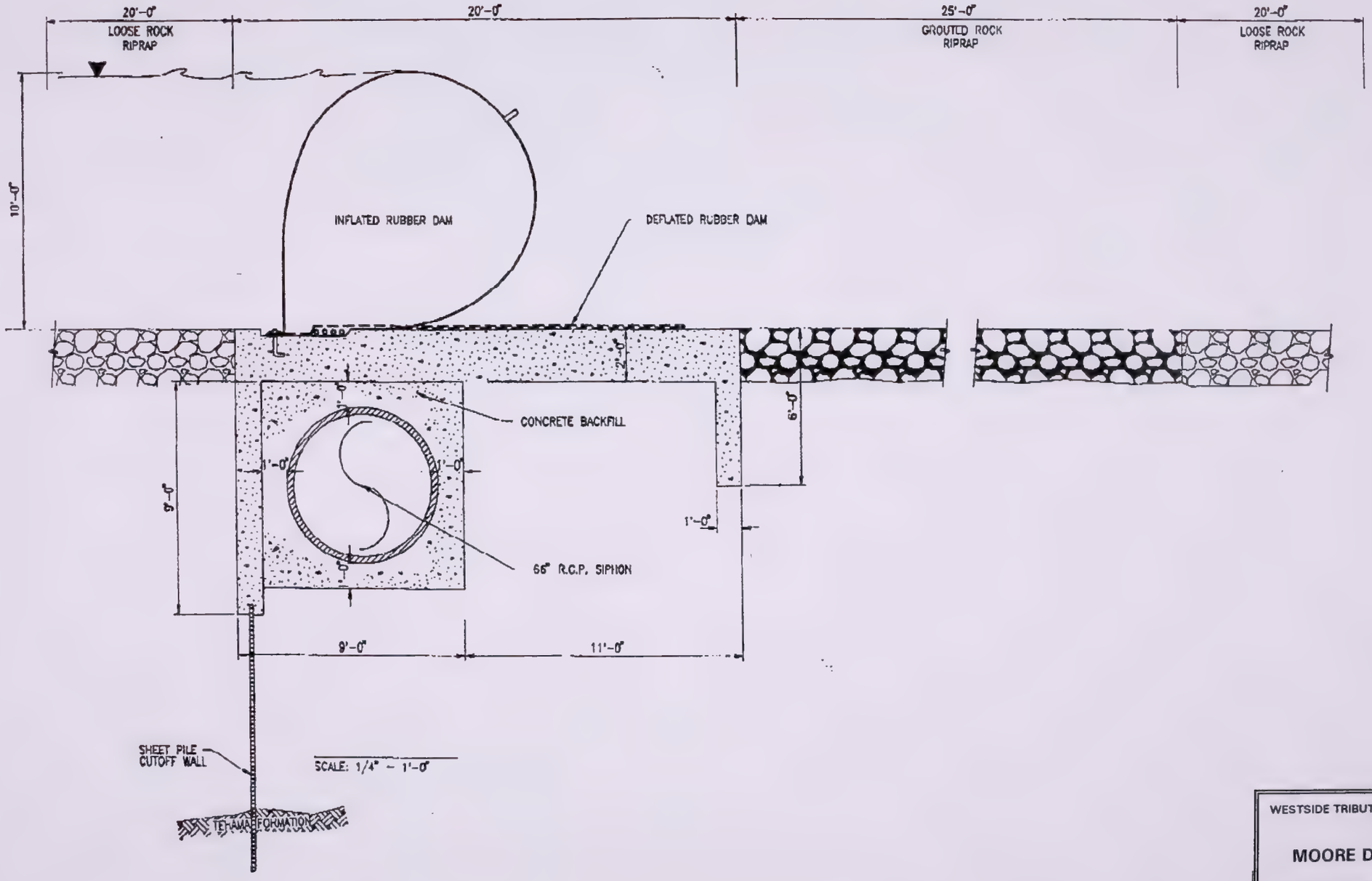


WESTSIDE TRIBUTARIES TO THE YOLO BYPASS
CALIFORNIA

MOORE DAM SECTION A-A

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 15



WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA

MOORE DAM SECTION A-A

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

PLATE 15

APPENDIX A

ENVIRONMENTAL EVALUATION

APPENDIX A

ENVIRONMENTAL EVALUATION

Environmental Evaluation

WESTSIDE TRIBUTARIES TO YOLO BYPASS
Reconnaissance Study
Northern California Streams

U.S. Army Corps of Engineers

Sacramento District
South Pacific Division

June 1994

ENVIRONMENTAL EVALUATION

NORTHERN CALIFORNIA STREAMS
WESTERN TRIBUTARIES TO YOLO BYPASS

TABLE OF CONTENTS

SECTION	PAGE
Table of Contents	i
Acronyms and Abbreviations	v
INTRODUCTION	1
Study Purpose	1
Study Authority	2
Study Area	2
Study Description	5
PROBLEMS AND OPPORTUNITIES	5
Flood Control	5
Environmental Restoration	6
Recreation	7
RELATED STUDIES AND PROJECTS	7
Corps Flood Control Studies and Projects	7
Corps Environmental Restoration Studies and Projects	7
Other Related Studies	9
FLOOD CONTROL ALTERNATIVE PLANS	10
Measures Eliminated from Further Study	10
Alternative 1 - No Action	11
Alternative 2 - Setback Levees	11
Alternative 3 - Channel Improvement	11
ENVIRONMENTAL RESTORATION ALTERNATIVE PLANS	12
Alternative 1 - No Action	12
Alternative 2 - Gravel Pit Wetland Restoration	12
Alternative 3 - Historic Fisheries Restoration	13
ENVIRONMENTAL SETTING	13
Climate	13
Topography	14
Geology and Soils	14
Air Quality	15
Hydrology	15
Water Quality	16

Noise 17
Socioeconomic Conditions 17
Land Use 18
Recreation 19
Hazardous, Toxic, and Radiological Waste (HTRW) Sites 19

KEY RESOURCES; HISTORIC AND EXISTING CONDITIONS 21
Vegetation 21
Wildlife 22
Fish 25
Rare, Threatened, and Endangered Species 27
Cultural Resources 30

KEY RESOURCES; FLOOD CONTROL AND RESTORATION IMPACTS 32
Vegetation 32
Wildlife 36
Fish 37
Rare, Threatened, and Endangered Species 39
Cultural Resources 41

MITIGATION AND ENHANCEMENT MEASURES 42
U.S. Fish and Wildlife Service Mitigation Planning Goals and Priorities 42
U.S. Fish and Wildlife Service Recommendations . . . 44
Corps' Strategic Mitigation Plan 47

ADDITIONAL STUDIES NEEDED 48
Fish and Wildlife 48
Rare, Threatened, and Endangered Species 49
Cultural Resources 49
Hazardous, Toxic, and Radiological Waste 50
Land Use 50
Restoration Benefits 50
Cost Effectiveness and Incremental Cost Analysis . . 50

COORDINATION 51

FINDINGS AND CONCLUSIONS 51

LIST OF PREPARERS AND REVIEWERS 53

BIBLIOGRAPHY 54

APPENDIXES

TABLES

PAGE

1. Length of Major Tributaries to Cache Creek 12
2. Hazardous Materials Sites 20
3. Fish Species and Hydrologic Conditions of the Westside 26
4. NDDB Report 29
5. U.S. Fish and Wildlife Mitigation Planning Goals . . 43

FIGURES

PAGE

1. Vicinity Map 3
2. Study Area 4
3. Gravel Mining Reach 8

APPENDIXES

A. Endangered Species Coordination
B. Planning Aid Report from FWS
C. California Natural Diversity Data Base
D. Common and Scientific Names of Species Discussed in the EE
E. Letters of Comment on the Notice of Initiation

ACRONYMS AND ABBREVIATIONS

APCD	Air Pollution Control District
CAR	Coordination Act Report
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
Corps	U.S. Army Corps of Engineers
CVHJV	Central Valley Habitat Joint Venture
DFG	California Department of Fish and Game
EE	Environmental Evaluation
EIS	Environmental Impact Statement
FWS	U.S. Fish and Wildlife Service
H:V	Ratio of horizontal distance to vertical distance
HEP	Habitat Evaluation Procedure
HTRW	Hazardous, Toxic, and Radiological Waste
NDDB	California Natural Diversity Data Base

ENVIRONMENTAL EVALUATION

NORTHERN CALIFORNIA STREAMS
WESTSIDE TRIBUTARIES TO YOLO BYPASS

INTRODUCTION

The purposes of this environmental evaluation (EE) are (1) to assist in developing and evaluating flood control alternatives, (2) to determine whether significant environmental impacts would occur from implementation of the final flood control alternative plans, (3) to assist in developing and evaluating environmental restoration alternatives, and (4) to determine whether significant environmental impacts would occur from implementation of the final environmental restoration alternative plans.

This EE also identifies environmental, cultural, and recreational studies that would be needed if a feasibility study is initiated in the future. This EE concludes that significant environmental impacts could result from implementation of the flood control alternative plans, therefore, preparation of an environmental impact statement (EIS) would be required during the feasibility phase. Insufficient information was available to conclude whether significant impacts could occur from implementation of either of the environmental restoration plans. Therefore, during the feasibility phase an EA could be prepared to clarify the need for an EIS, or an EIS may be prepared without first completing an EA.

Study Purpose

The purpose of the reconnaissance study is to determine the potential for Federal participation in increasing the levels of flood protection along the westside tributaries to the Yolo Bypass. Consistent with the U.S. Army Corps of Engineers (Corps) environmental mission, an additional purpose of this investigation is to identify potential environmental restoration plans in the study area which might be carried out under directives of Sections 704, 906, and 1135 of the Water Resources Development Act of 1986. Recreational opportunities consistent with the study purpose will also be identified.

Study Authority

This study was authorized by the Flood Control Act of 1962 (Public Law 87-874). In the Energy and Water Development Appropriations Act of 1993 (Public Law 102-377), Congress directed the Corps to conduct a "reconnaissance study of flooding problems in the westside tributaries, Putah and Cache Creeks, of the Yolo Bypass." The study was initiated in April 1993 at the request of the Yolo County Board of Supervisors.

Study Area

Figure 1 shows a general map of the watershed. It extends from the western levees of the Yolo Bypass into the eastern foothills of the Coast Range and includes parts of Yolo, Colusa, Solano, Napa, and Lake Counties (see Figure 1). The focus of the study is within Yolo County and includes three sub-basins of the Sacramento River basin: Cache Creek, Willow Slough, and Putah Creek. Specific stream reaches with flood control and environmental restoration needs include Cache Creek between Capay and the Cache Creek settling basin, Willow Slough, and Putah Creek from Davis to the South Fork Putah Creek (see Figure 2). The primary communities in the study area include Woodland, Davis, Yolo, Madison, and Esparto.

Cache Creek Basin. The Cache Creek basin is located about 20 miles west of Sacramento and lies on the eastern slope of the Coast Range (Corps 1975:1). The basin drains 1,150 square miles and includes portions of Colusa, Lake, and Yolo Counties. The basin is naturally divided into two areas: the Clear Lake area, including tributaries to the lake, and the Cache Creek area, composed of Cache Creek and its tributaries. This reconnaissance study focuses on the lower Cache Creek area.

Gravel Mining Reach. The gravel mining reach extends for approximately 14.5 miles along Cache Creek between Capay and Yolo. This area has been the site of gravel extraction since at least the 1930s (Zentner & Zentner 1993:4).

Willow Slough Basin. The Willow Slough basin is located about 30 miles west of Sacramento and includes Willow Slough, Willow Slough Bypass, Dry Slough, and other smaller tributaries. Most of this basin is located in Yolo County with the western most boundary lying in Napa County. The Willow Slough basin drains into the Yolo Bypass via the Willow Slough Bypass and includes about 200 square miles (Corps 1993:3).

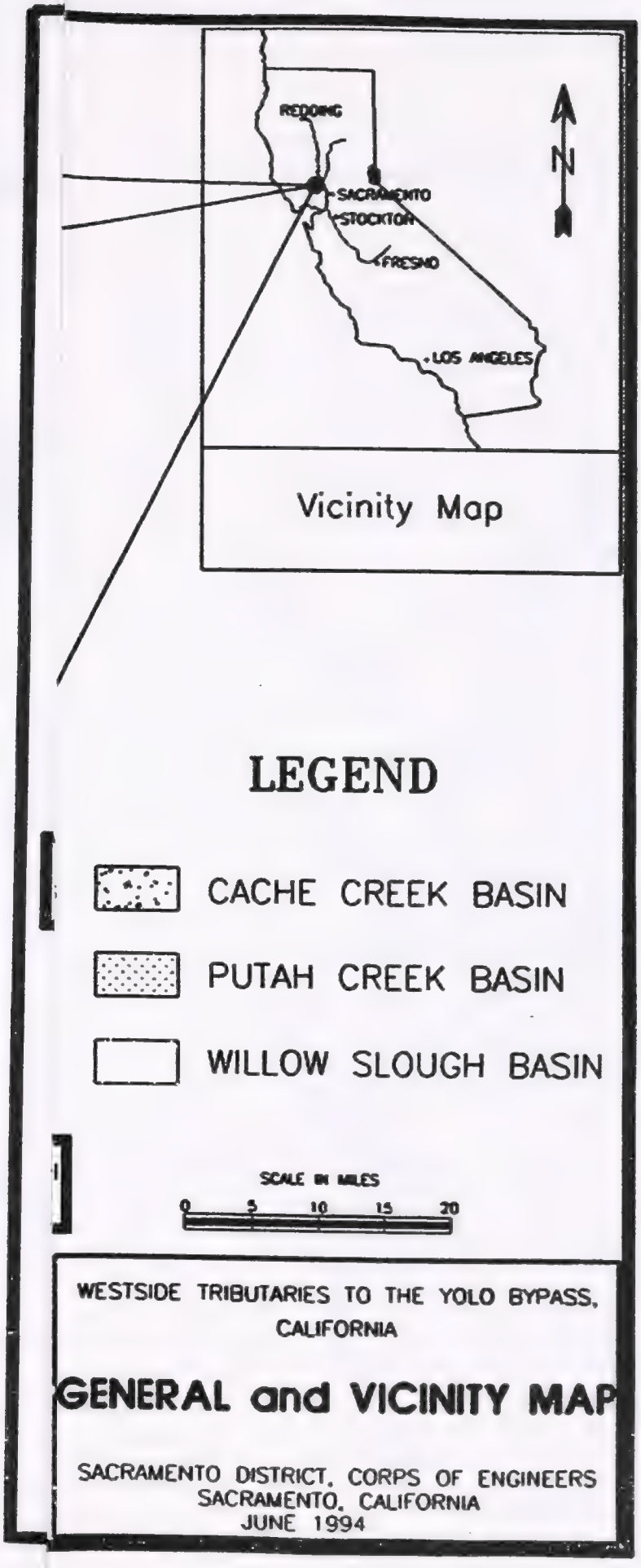

REDDING
SACRAMENTO
STOCKTON
FRESNO
LOS ANGELES
N
Vicinity Map
LEGEND
CACHE CREEK BASIN
PUTAH CREEK BASIN
WILLOW SLOUGH BASIN
SCALE IN MILES
0 5 10 15 20
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA
GENERAL and VICINITY MAP
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Figure 1

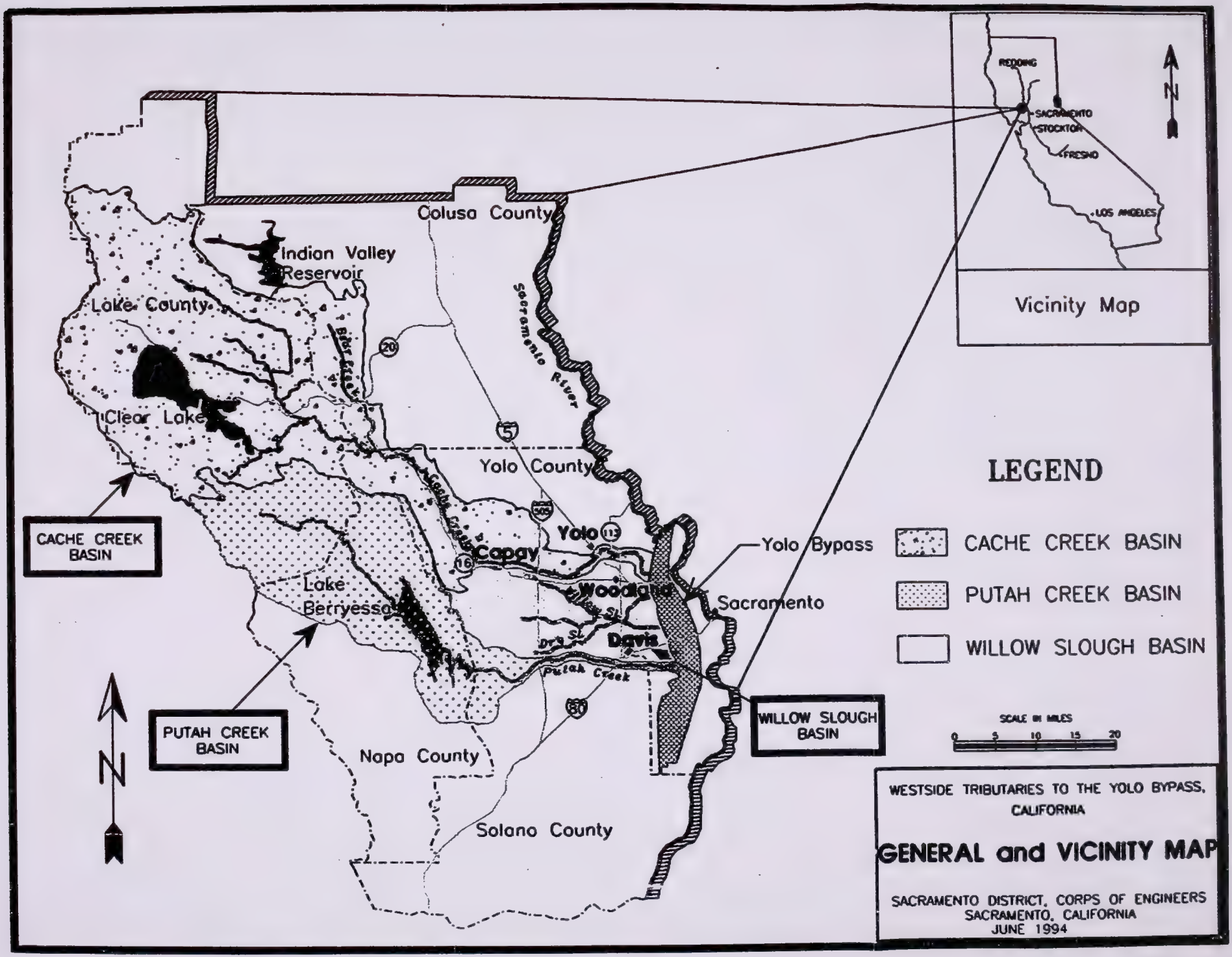

Colusa County
Indian Valley Reservoir
Lake County
Clear Lake
Cache Creek
Bear Creek
Sacramento River
Yolo County
Capay
Yolo
Woodland
Davis
Dry Slough
Putah Creek
Lake Berryessa
Napa County
Solano County
Yolo Bypass
Sacramento
CACHE CREEK BASIN
PUTAH CREEK BASIN
WILLOW SLOUGH BASIN
N
REDDING
SACRAMENTO
STOCKTON
FRESNO
LOS ANGELES
Vicinity Map
LEGEND
CACHE CREEK BASIN
PUTAH CREEK BASIN
WILLOW SLOUGH BASIN
SCALE IN MILES
0 5 10 15 20
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA
GENERAL and VICINITY MAP
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Figure 1

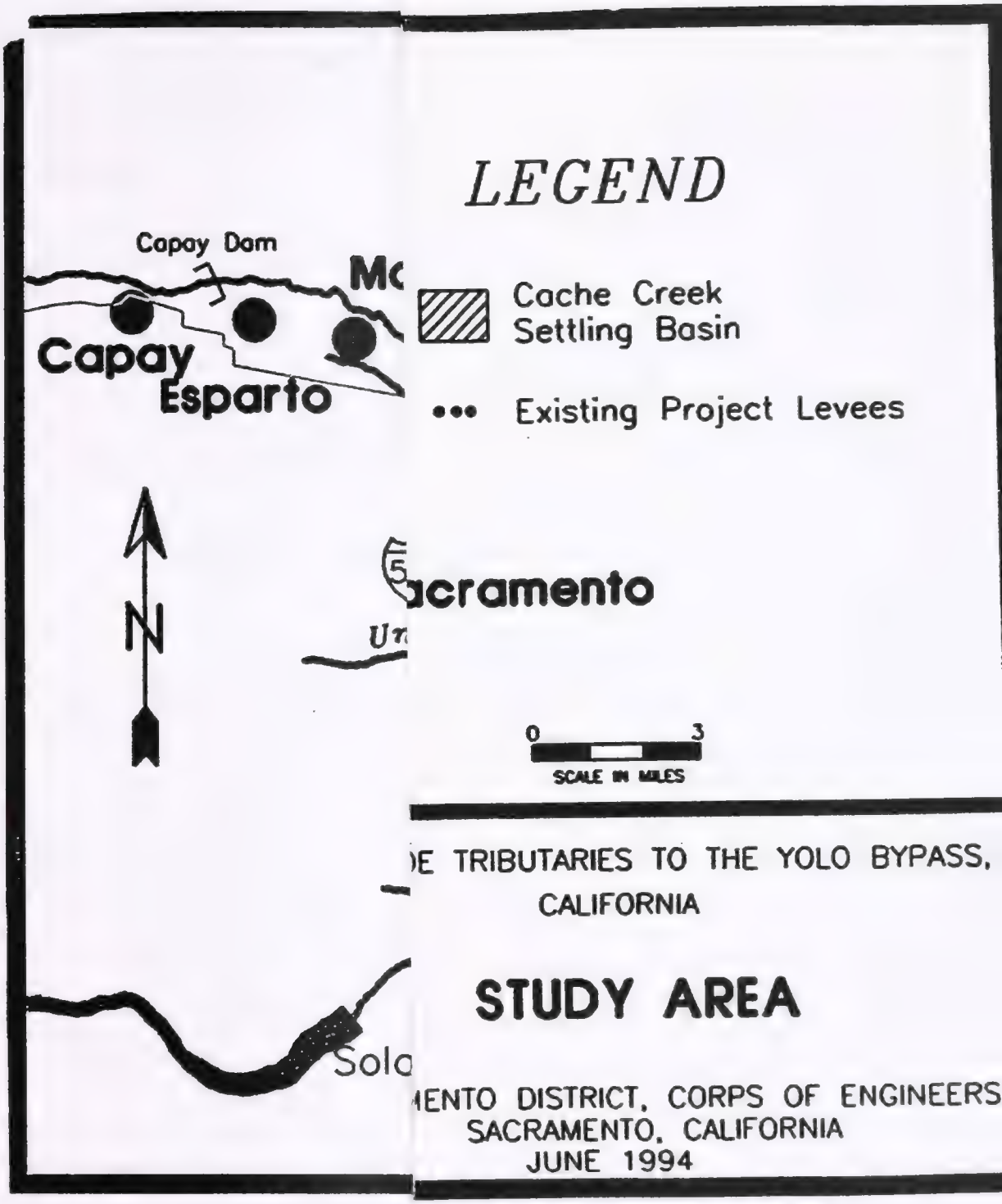

LEGEND
Capay Dam
Capay
Esparto
Cache Creek
Settling Basin
Existing Project Levees
N
0
3
SCALE IN MILES
TRIBUTARIES TO THE YOLO BYPASS,
CALIFORNIA
STUDY AREA
DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Figure 2

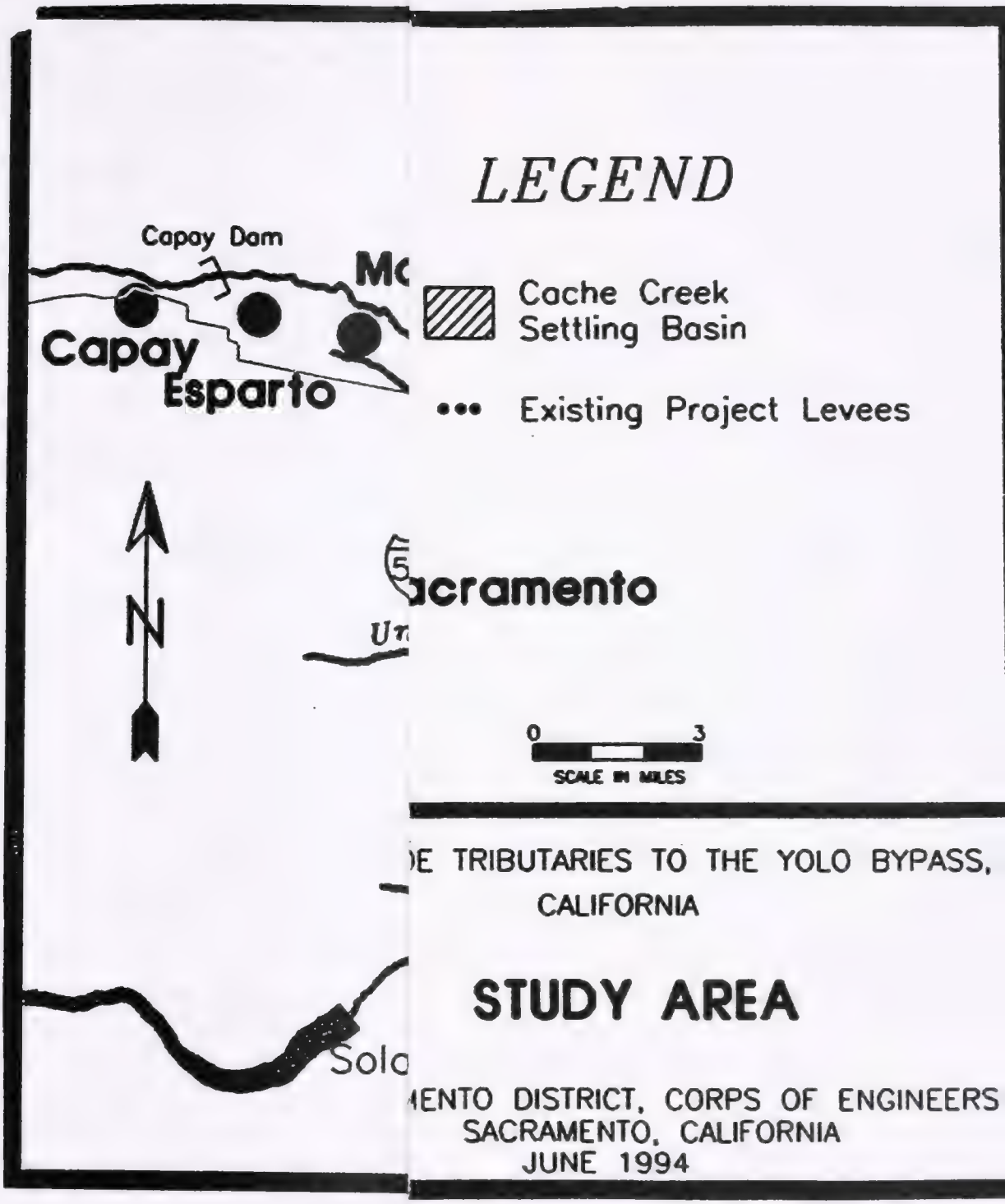

LEGEND
Capay Dam
Capay
Esparto
Cache Creek
Settling Basin
Existing Project Levees
N
0
3
SCALE IN MILES
E TRIBUTARIES TO THE YOLO BYPASS,
CALIFORNIA
STUDY AREA
ENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Figure 2

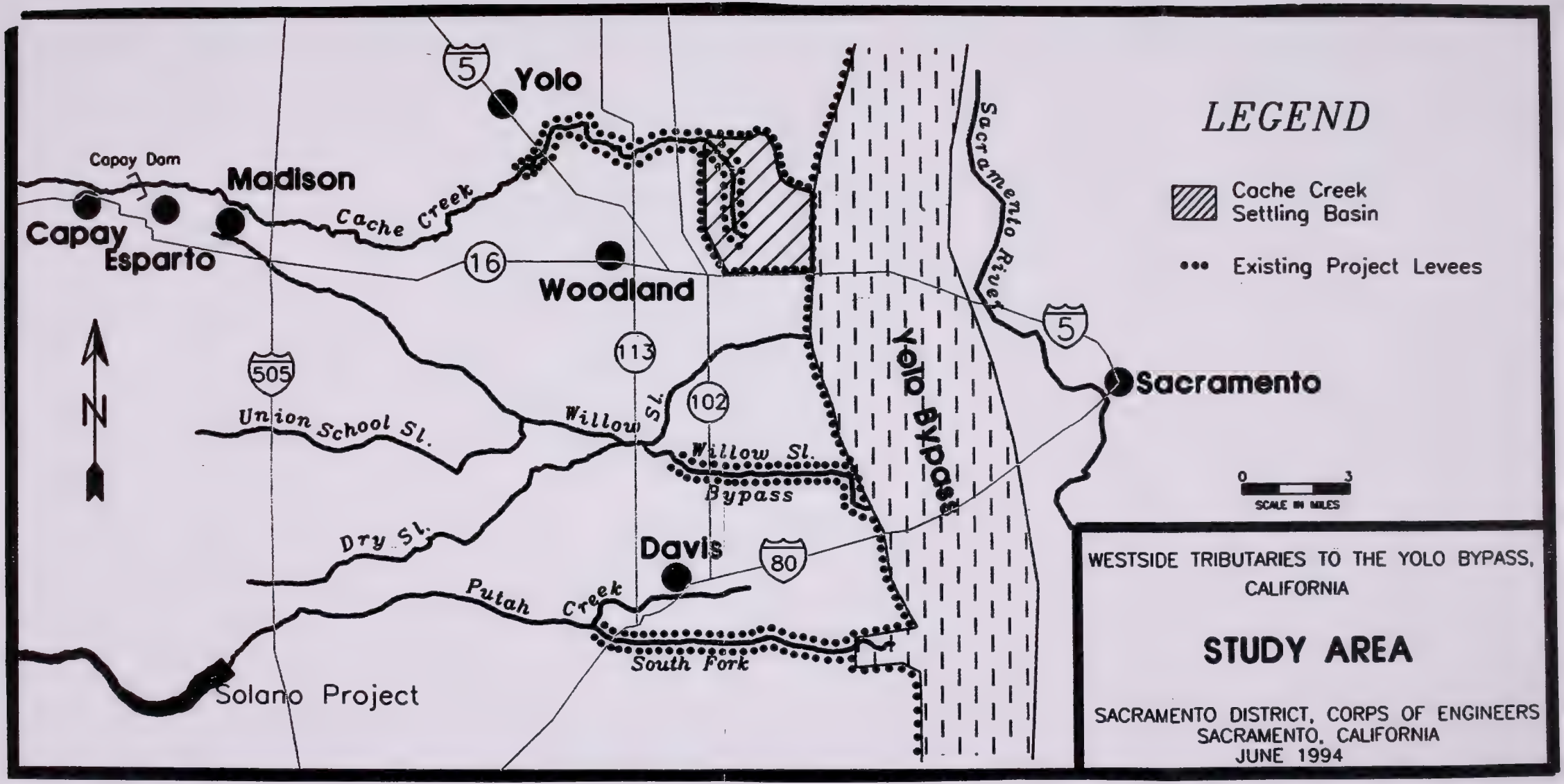

Yolo
5
Capay Dam
Madison
Cache Creek
Capay
Esparto
16
Woodland
113
505
Union School Sl.
Willow Sl.
102
Willow Sl.
Bypass
Yolo Bypass
Sacramento River
5
Sacramento
N
Dry Sl.
Davis
80
Putah Creek
South Fork
Solano Project
LEGEND
Cache Creek
Settling Basin
Existing Project Levees
0
3
SCALE IN MILES
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS,
CALIFORNIA
STUDY AREA
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Figure 2

Putah Creek Basin. The Putah Creek basin is located about 20 miles southwest of Sacramento and includes Lake Berryessa, a reservoir created by the construction of Monticello Dam. Putah Creek originates above the lake and flows east through the Monticello Dam to the Yolo Bypass (via South Fork Putah Creek). Part of the flow is diverted south at Lake Solano, a constructed irrigation reservoir, by the Solano Water District. The basin includes about 710 square miles.

Study Description

The reconnaissance study is investigating flooding problems and environmental restoration opportunities along the westside tributaries to the Yolo Bypass, from Cache Creek in the north to Putah Creek in the south, and is developing and evaluating potential alternative solutions. The focus of the flood control effort is on those alternatives that increase the level of flood protection. Results of the study will be presented in the final Reconnaissance Report. If one or more feasible alternatives are identified and an interested non-Federal sponsor is identified, the study may progress into a feasibility study.

PROBLEMS AND OPPORTUNITIES

Flood Control

Flooding in the study area is caused mainly by high-intensity rainstorms runoff during winter and spring. Historic flood records show flooding in Woodland, Davis, and smaller communities and agricultural lands along Putah Creek, Willow Slough, and Cache Creek. Construction of Monticello Dam in the late 1950's reduced flood problems along Putah Creek. However, some flooding occurred along Willow Slough in October 1962. In 1983, floodwater from an estimated 90-year event, rose to the top of some levee reaches on Cache Creek just downstream of Interstate Highway 5. A levee failure at this location could have affected Woodland, a city with a population of about 42,000.

Extensive groundwater pumping has caused land subsidence in the study area. This subsidence has decreased the uncertainty allowance of project levees. As a result, Cache Creek and Willow Slough may not safely convey floodflows from 100-year or larger events. Currently, Cache Creek and Willow Slough levees can contain up to 10-year flood event flows, and Putah Creek levees can contain up to 100-year flood event flows.

During the past 20 years, there has been extensive controversy over the environmental impacts of the gravel mining

Putah Creek Basin. The Putah Creek basin is located about 20 miles southwest of Sacramento and includes Lake Berryessa, a reservoir created by the construction of Monticello Dam. Putah Creek originates above the lake and flows east through the Monticello Dam to the Yolo Bypass (via South Fork Putah Creek). Part of the flow is diverted south at Lake Solano, a constructed irrigation reservoir, by the Solano Water District. The basin includes about 710 square miles.

Study Description

The reconnaissance study is investigating flooding problems and environmental restoration opportunities along the westside tributaries to the Yolo Bypass, from Cache Creek in the north to Putah Creek in the south, and is developing and evaluating potential alternative solutions. The focus of the flood control effort is on those alternatives that increase the level of flood protection. Results of the study will be presented in the final Reconnaissance Report. If one or more feasible alternatives are identified and an interested non-Federal sponsor is identified, the study may progress into a feasibility study.

PROBLEMS AND OPPORTUNITIES

Flood Control

Flooding in the study area is caused mainly by high-intensity rainstorms runoff during winter and spring. Historic flood records show flooding in Woodland, Davis, and smaller communities and agricultural lands along Putah Creek, Willow Slough, and Cache Creek. Construction of Monticello Dam in the late 1950's reduced flood problems along Putah Creek. However, some flooding occurred along Willow Slough in October 1962. In 1983, floodwater from an estimated 90-year event, rose to the top of some levee reaches on Cache Creek just downstream of Interstate Highway 5. A levee failure at this location could have affected Woodland, a city with a population of about 42,000.

Extensive groundwater pumping has caused land subsidence in the study area. This subsidence has decreased the uncertainty allowance of project levees. As a result, Cache Creek and Willow Slough may not safely convey floodflows from 100-year or larger events. Currently, Cache Creek and Willow Slough levees can contain up to 10-year flood event flows, and Putah Creek levees can contain up to 100-year flood event flows.

During the past 20 years, there has been extensive controversy over the environmental impacts of the gravel mining

operations on land and water resources in the study area. In 1979, the Yolo County Board of Supervisors adopted interim in-channel regulations and a reclamation ordinance to control gravel mining along Cache Creek. Yolo County is in the process of preparing a long-term resource management plan for Cache Creek. The goals of the plan include providing adequate flood-carrying capacity in the stream channel, minimizing bank erosion from stream action, encouraging riparian vegetation and wildlife habitat, and controlling gravel mining.

Environmental Restoration

Federal, State, and local flood control and water development projects have altered natural flow and drainage patterns in the Central Valley. As a result, major losses of aquatic, wetland, and riparian habitats have occurred throughout the valley. Direct and indirect impacts from these projects have contributed to a serious decline in the biological resources in the Yolo Basin, including the westside tributaries.

Major flood control projects constructed by the Corps include the Sacramento River Flood Control Project and Sacramento River Bank Protection Project. Implementation of these projects along the river and streams has contributed to direct impacts on riparian and wetland habitat through construction of levees and bypasses, regulation of floodflows, and removal of vegetation and sediment. These activities have displaced streamside plants and denied floodwater to wetland and riparian areas. Vegetation and associated wildlife species continue to be adversely affected as these habitats diminish in size or deteriorate in quality.

Clearing channels and constructing levees have degraded aquatic habitat along the westside tributaries, resulting in altered fish community composition and reduced fish populations. Native fish, especially anadromous species such as Pacific lamprey, chinook salmon, and steelhead, have been directly affected. Modification of the hydrological conditions has eliminated spawning areas on Cache Creek and reduced spawning habitat on Putah Creek.

The westside tributaries have also been indirectly affected by the implementation of water-related projects and gravel mining. Reduced floodflows have facilitated, and may have encouraged, the conversion of historic riparian and wetland habitats to urban and agricultural areas. This urban and agricultural development has largely eliminated previously abundant fish and wildlife habitat values.

Since Corps projects have influenced the natural conditions in the area, there is a significant opportunity to restore

ecological resources (including fish, wildlife, and plants) that are now degraded. One potential restoration site is the gravel mining area along Cache Creek. This area currently has low-to-moderate wildlife value due to its highly disturbed wash-like character. The abandoned gravel pits are generally devoid of woody vegetation, have low wildlife habitat value, and lack natural physical characteristics like topographic variation. Restoration of the mined gravel pits would benefit the entire creek. Figure 3 shows the locations of the abandoned gravel pits.

Recreation

According to the Yolo County Planning Department, no developed recreation areas exist along the westside tributaries. Any developed recreation areas in the study area are mainly found near Davis and Woodland. Yolo County and these cities are considering the development of plans for hiking, biking, and equestrian trails. In concept, new trails would link existing trails in Woodland and Davis, and additional trails would connect these areas with West Sacramento and Sacramento. There is also interest in providing biking access to proposed wetland sites in, and adjacent to, the Yolo Bypass and a proposed wetlands visitor center. Recreation elements could be incorporated into future flood control plans.

RELATED STUDIES AND PROJECTS

Corps Flood Control Studies and Projects

Cache Creek Basin (Lake County). In October 1992, the Corps completed a reconnaissance study which evaluated the need for additional flood protection in the Clear Lake area of the Cache Creek basin. The study area included Clear Lake, its tributaries, and Cache Creek from its outlet to the Cache Creek Dam. A feasible alternative and an interested non-Federal sponsor, Lake County, were identified. This study is eligible to continue into feasibility studies if Lake County is able and willing to participate in cost-sharing requirements.

Corps Environmental Restoration Studies and Projects

Yolo Basin Wetlands (Section 1135). The purpose of this project is to restore historic wetlands within the Yolo Basin area and contribute to a larger interagency program to improve the quality of environmental resources in the State and nationwide. The project would modify the Yolo Bypass, a feature

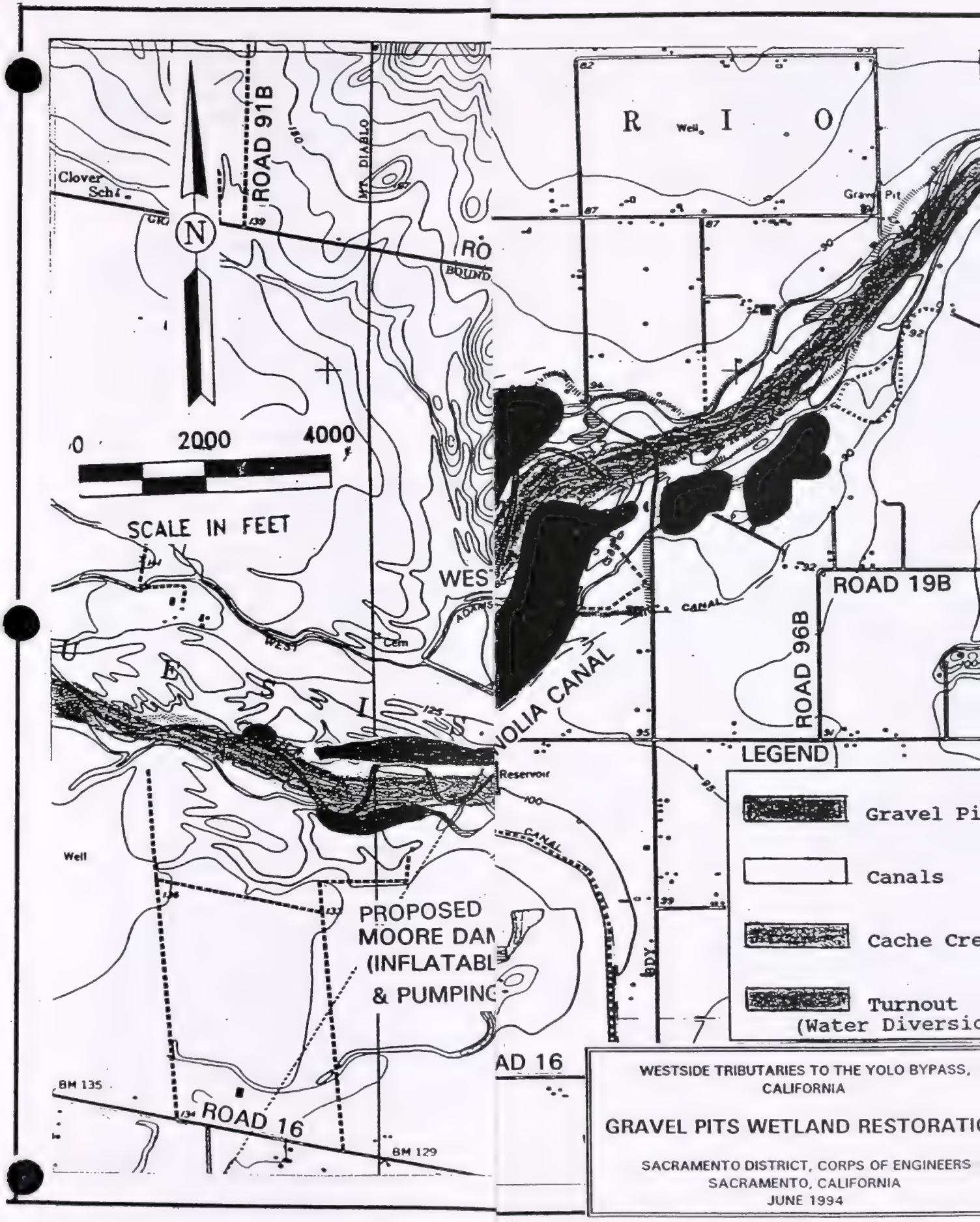

N
0
2000
4000
SCALE IN FEET
ROAD 91B
MT. DIABLO
Clover Sch
R I O
Well
Gravel Pit
ROAD 19B
ROAD 96B
CANAL
LEGEND
Gravel Pi
Canals
Cache Cre
Turnout
(Water Diversio
Reservoir
Well
PROPOSED
MOORE DAM
(INFLATABL
& PUMPING
ROAD 16
BM 135
BM 129
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA
GRAVEL PITS WETLAND RESTORATIO
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Figure 3

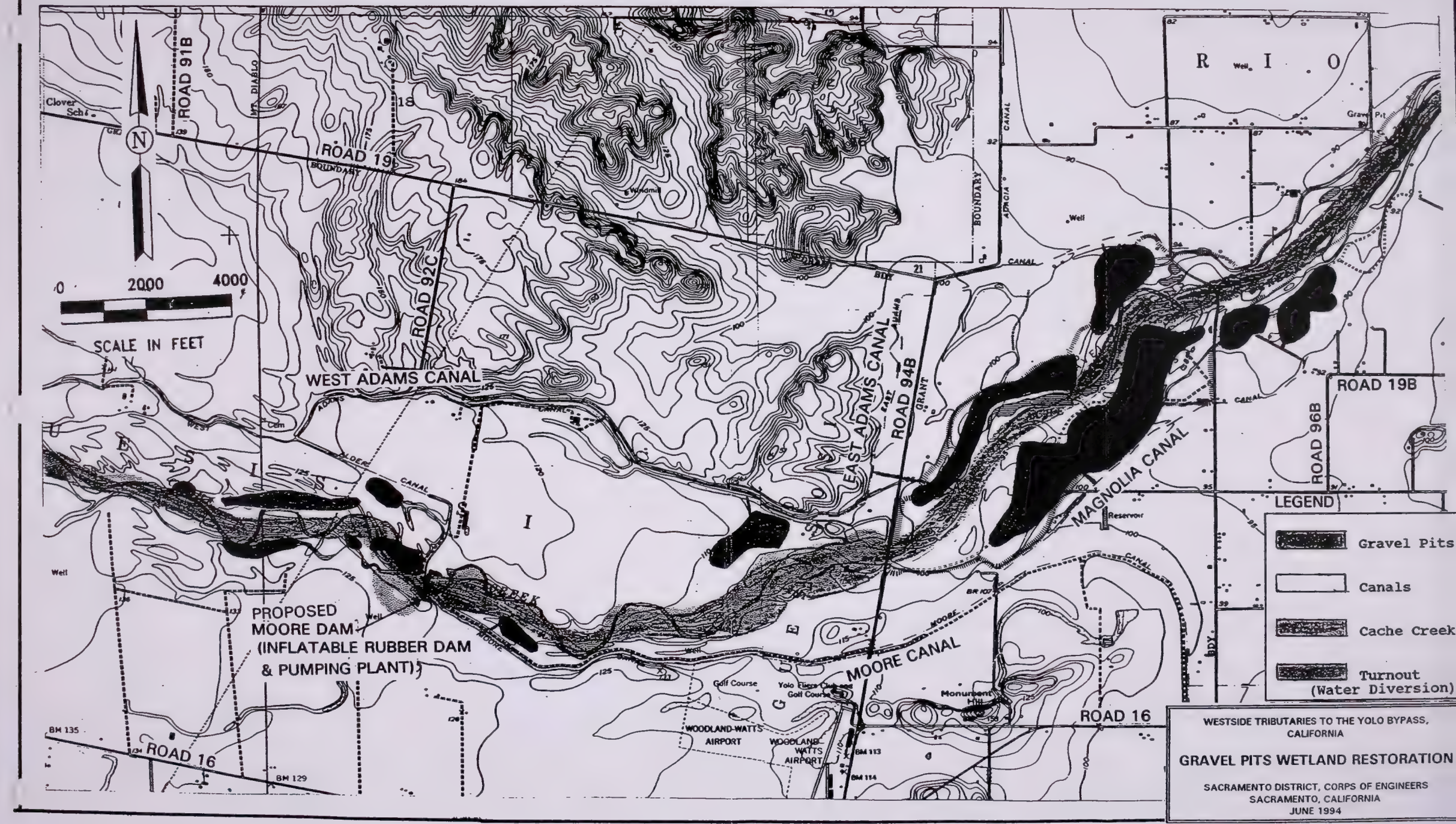

ROAD 91B
ROAD 19
ROAD 92C
WEST ADAMS CANAL
EAST ADAMS CANAL
ROAD 94B
MAGNOLIA CANAL
ROAD 19B
ROAD 96B
MOORE CANAL
ROAD 16
PROPOSED
MOORE DAM
(INFLATABLE RUBBER DAM
& PUMPING PLANT)
CACHE CREEK
WOODLAND-WATTS
AIRPORT
Golf Course
Monument Hill
Reservoir
Well
Windmill
Clover Sch.
Gravel Pit
BOUNDARY
CANAL
BM 135
BM 129
BM 113
BM 114
0 2000 4000
SCALE IN FEET
LEGEND
Gravel Pits
Canals
Cache Creek
Turnout
(Water Diversion)
WESTSIDE TRIBUTARIES TO THE YOLO BYPASS, CALIFORNIA
GRAVEL PITS WETLAND RESTORATION
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
JUNE 1994

Figure 3

of the Sacramento River Flood Control Project, by restoring wetlands on two sites within the Yolo Bypass. The 3,000-acre Putah Creek Sinks Site and 480-acre Yolo Causeway Site are currently used for agriculture. The work involves constructing low berms, canals, and water control structures to restore seasonal and permanent wetlands, riparian woodland, and grassland/upland. Construction is scheduled to begin in August 1994.

Yolo Basin Wetlands, Davis Site, California. The purpose of this project is to restore historic wetlands on about 400 acres of farmland northeast of Davis. This land is contiguous to the Yolo and Willow Slough Bypasses, which are features of the Sacramento River Flood Control Project. The work involves restoring seasonal and permanent wetlands and riparian woodland by constructing canals, water control structures, and dikes. A Project Modification Report was completed in June 1994.

Other Related Studies

Fish and Wildlife Resource Management Options for Lower Putah Creek, California. Congress directed the FWS to prepare a planning document that identifies the issues affecting fish and wildlife resources on Putah Creek and establishes a series of priority actions to maintain and improve those resources. Implementation of the management measures would depend primarily on the support and cooperation of private landowners as well as numerous Federal, State, and local agencies and private groups. The planning area is the Putah Creek corridor from Monticello Dam to the Putah Creek Sinks. Measures for fish and wildlife protection and enhancement are (1) flow management, (2) vegetation management and flood protection, (3) physical enhancement of riparian habitats, (4) management of fisheries in the inter-dam reach, (8) vegetation enhancement, and (9) vegetation management and flood protection. The final report was completed in August 1993 and released to the public.

Suitability Analysis for Enhancing Wildlife Habitat in the Yolo Basin. This document was prepared for the Central Valley Habitat Joint Venture (CVHJV) and California Wetlands Foundation with funding provided by the California Department of Fish and Game (DFG), the Conaway Conservancy, and the U.S. Army Corps of Engineers, to identify opportunities for and constraints to the creation and management of wetland, riparian, grassland, and oak woodland habitats in the Yolo Basin. Another major objective of the study was to identify and evaluate the diverse array of agricultural land uses and crop types in the study area and to recognize the important secondary benefits of agriculture to various species of wildlife. The study presents management guidelines and habitat suitability maps for both private and

of the Sacramento River Flood Control Project, by restoring wetlands on two sites within the Yolo Bypass. The 3,000-acre Putah Creek Sinks Site and 480-acre Yolo Causeway Site are currently used for agriculture. The work involves constructing low berms, canals, and water control structures to restore seasonal and permanent wetlands, riparian woodland, and grassland/upland. Construction is scheduled to begin in August 1994.

Yolo Basin Wetlands, Davis Site, California. The purpose of this project is to restore historic wetlands on about 400 acres of farmland northeast of Davis. This land is contiguous to the Yolo and Willow Slough Bypasses, which are features of the Sacramento River Flood Control Project. The work involves restoring seasonal and permanent wetlands and riparian woodland by constructing canals, water control structures, and dikes. A Project Modification Report was completed in June 1994.

Other Related Studies

Fish and Wildlife Resource Management Options for Lower Putah Creek, California. Congress directed the FWS to prepare a planning document that identifies the issues affecting fish and wildlife resources on Putah Creek and establishes a series of priority actions to maintain and improve those resources. Implementation of the management measures would depend primarily on the support and cooperation of private landowners as well as numerous Federal, State, and local agencies and private groups. The planning area is the Putah Creek corridor from Monticello Dam to the Putah Creek Sinks. Measures for fish and wildlife protection and enhancement are (1) flow management, (2) vegetation management and flood protection, (3) physical enhancement of riparian habitats, (4) management of fisheries in the inter-dam reach, (8) vegetation enhancement, and (9) vegetation management and flood protection. The final report was completed in August 1993 and released to the public.

Suitability Analysis for Enhancing Wildlife Habitat in the Yolo Basin. This document was prepared for the Central Valley Habitat Joint Venture (CVHJV) and California Wetlands Foundation with funding provided by the California Department of Fish and Game (DFG), the Conaway Conservancy, and the U.S. Army Corps of Engineers, to identify opportunities for and constraints to the creation and management of wetland, riparian, grassland, and oak woodland habitats in the Yolo Basin. Another major objective of the study was to identify and evaluate the diverse array of agricultural land uses and crop types in the study area and to recognize the important secondary benefits of agriculture to various species of wildlife. The study presents management guidelines and habitat suitability maps for both private and

public or nonprofit landowners to consider if they choose to participate in wildlife support programs and wetlands restoration. The study area for this project comprises about 110,000 acres in the Yolo Basin in northern California's Sacramento Valley.

FLOOD CONTROL ALTERNATIVE PLANS

Since the existing level of flood protection on Putah Creek is 100 years, no flood control measures were considered for Putah Creek. Structural measures were not considered for Willow Slough due to potentially high construction costs and limited urban development. However, nonstructural measures were considered for Willow Slough, and structural and nonstructural measures were considered for Cache Creek.

Measures Eliminated from Further Study

Nonstructural. Nonstructural measures reduce flood-related threats to public safety and property at the point of damage rather than by controlling the floodwater. The nonstructural measure included a combination of several nonstructural methods: (1) temporary closure of structures (buildings, roads, etc.); (2) ring levees; (3) floodwalls; and (4) structural relocations. However, this measure was not logistically or economically feasible on Cache Creek or Willow Slough and was eliminated from further consideration.

Upstream Storage in Cache Creek Basin. Upstream storage would have been accomplished with a multipurpose dam and reservoir just upstream of Rumsey at the Blue Ridge site. The dam would have included a 300-foot-wide overflow type spillway. The proposed reservoir would have a surface area of 7,000 acres and a storage capacity of 945,000 acre-feet. The reservoir would provide storage space for water supply, sediment, and flood control. However, no local support has been identified so this measure was not considered further.

Upstream Detention Basin on Cache Creek. Three potential detention basin sites in the Cache Creek basin were evaluated to determine their effectiveness in reducing floodflows along Cache Creek. The three sites were Bear Creek, Wilson Valley, and downstream of Capay Dam. The Bear Creek site was located about 11 miles upstream from its confluence with Cache Creek. This on-stream site was identified by the State Department of Water Resources in the early 1970's as part of their Eel River project. The Wilson Valley site was located on Cache Creek about 5 miles downstream from the confluence with the North Fork Cache Creek.

The Capay site was located downstream of Capay Dam. Work at this site involved constructing off-stream detention ponds adjacent to Cache Creek.

However, detention basins at the Bear Creek and Wilson Valley sites would not significantly reduce floodflows or flood damages, so these two sites were not considered further. The Capay site was also dropped from further consideration because of large land requirements, as well as construction and operation difficulties.

Alternative 1 - No Action

Under this plan, no action would be taken by the Federal Government to reduce flood problems and conditions in the study area. No action means that the existing conditions would continue.

Alternative 2 - Setback Levees

About 16 miles of levee along both banks from about Road 102 to Road 94B would be raised and/or require new construction to provide 100-year level of flood protection. Existing levee heights range from 5 to 15 feet above the landside ground surface, and crown widths are about 12 feet wide. Levee modification involved 3H:1V waterside slopes and 2H:1V landside slopes, as recommended by Phase III of the Sacramento River Flood Control System Evaluation. Some reaches of the levees on Cache Creek have less than the design crown width and design heights, and levee embankment slopes are flatter than the design specifications. In some cases, the differences are significant and suggest levee embankment subsidence and slumping at the base of the levees.

Levee raising on some reaches of Cache Creek would cause flow velocities to exceed 10 feet per second, which could cause scouring, erosion, and failure of the levees. In order to stabilize the channel bottom and levee side slopes and reduce flow velocities, setback levees and slope protection measures would be constructed as required. In some cases, the levee reaches would require slope protection to stabilize the slope from slumping or erosion.

Alternative 3 - Channel Improvement

Channel improvements from Road 94B to Road 102 would involve excavating about 10 miles of Cache Creek, constructing or raising about 8 miles of levees, rebuilding bridges and railroad crossings to accommodate the increased channel width and depth,

removing riparian vegetation, and removing other obstructions and sediment. In order to contain the floodflow without causing additional erosion or slumping of the channel banks, slope protection would be needed.

Table 1 shows details of Alternatives 2 and 3.

Table 1. Length of Major Project Features for Flood Control Alternative Plans.

Length of Major Project Features (miles)	Alternative 2 Setback Levee		Alternative 3 Channel Improvement	
	100-Year	200-Year	100-Year	200-Year
Channel Excavation	–	–	9.7	9.7
New Levees				
Left Bank	6.7	7.1	1.4	1.4
Right Bank	7.5	7.5	1.7	1.7
Raised Existing Levee				
Left Bank	9.1	9.1	6.7	6.7
Right Bank	7.4	7.4	6.0	6.7
Slope Protection				
Left Bank	1.2	1.2	1.5	1.5
Right Bank	2.7	2.7	1.3	1.3

ENVIRONMENTAL RESTORATION ALTERNATIVE PLANS

Alternative 1 - No Action

Under this plan, no action would be taken by the Federal Government to restore the environment in the study area. No action means that the existing conditions would continue.

Alternative 2 - Gravel Pit Wetland Restoration

Along the reaches of Cache Creek from Capay to just west of Interstate 5 near Yolo are abandoned gravel pits. The local flood control agency and the residents of Yolo County are interested in restoring the gravel pits to seasonal or permanent wetlands. Where appropriate, these wetlands would be surrounded by restored riparian woodland, and linked by means of this woodland to existing creekside riparian forest.

Restoration would require minor regrading of some pits, planting with native species, and using the existing irrigation

canal system to route winter and spring flows into these pits. The water would support a diverse mix of seasonal and permanent marshes and riparian woodlands while also recharging groundwater aquifers through some of the pits.

There are 13 gravel pits which are good candidates for wetland restoration. These pits range in size from less than 8 acre to about 50 acres. The depths vary from 20 feet to 30 feet. These pits are adjacent to Cache Creek and to the Moore Canal. Water would be diverted from Cache Creek through Moore Canal and Adams Canal to these pits. These restored pits would function primarily as wildlife habitat and could play a role in groundwater recharge.

Alternative 3 - Historic Fisheries Restoration

Restoring anadromous fish to Cache Creek could be done by increasing flows during the spawning season and constructing fish ladders and/or low flow gates at various obstacles. These obstacles occur at the base of the Cache Creek Settling Basin to the Yolo Bypass and Capay Dam. Eliminating migration obstacles could give fish access to miles of spawning gravel in the upper Cache Creek and other tributaries to Cache Creek.

ENVIRONMENTAL SETTING

Climate

The three basins (Cache Creek, Willow Slough, and Putah Creek) have a mediterranean climate characterized by hot, dry summers and cool, wet winters. The dry season extends from May through September, followed by a rainy season that lasts from October through April. The temperature may drop below freezing during the winter and reach over 100 degrees Fahrenheit during the summer. Snowfall is rare.

Cache Creek Basin. Normal annual precipitation varies from a minimum of about 17 inches near the community of Yolo, and averages about 32 inches over the entire basin.

Willow Slough Basin. Normal annual precipitation can range from about 18 inches in the east to 34 inches in the higher elevations.

Putah Creek Basin. Normal precipitation varies from a maximum of more than 80 inches along the western edge of the basin to a minimum of about 30 inches in lower elevations, and averages about 49 inches over the basin.

Topography

The Sacramento River basin is bounded by the Trinity Mountains on the north, the Sierra Nevada on the east, and the North Coast Range on the west, and joins the San Joaquin Valley on the south. The Sacramento Valley is the central portion of the basin and extends 150 miles from Red Bluff in the north to Suisun Bay in the south. The valley varies 10 to 40 miles in width and ranges in elevation from about 300 feet above sea level to about 5 feet below sea level.

The elevation of the land west of the Yolo Bypass increases toward the coastal mountain range. Levees constructed for flood control and land reclamation in the 1800's and 1900's provide some topographic relief on the flat valley floor.

Cache Creek Basin. The topography of this basin varies from the steep, rugged hill slopes of the Coast Range to the gentle slopes of the valley floor near Capay, located on the western edge of the large alluvial plain (Corps 1993:2). Elevation ranges from about 6,000 feet on the northern basin perimeter to about sea level near Yolo. Stream channel gradients in the upper watershed are quite steep (Simons, Li & Associates, Inc. 1987:2).

Willow Slough Basin. The western portion of the basin is characterized by steep slopes and extends into the Coast Range to elevations of approximately 2,500 feet (Corps 1993:3-4). The eastern portion of the watershed consists of slightly sloping elevations down to 65 feet.

Putah Creek Basin. The upper Putah Creek basin ranges in elevation from about 4,700 feet in the western mountains to 900 feet near Winters (Corps 1993:3).

Gravel Mining Reach. The gravel mining reach extends for approximately 14.5 miles along Cache Creek between Capay and

Geology and Soils

Much of the study area is part of the Great Valley Geomorphic province of California. The broad valley was filled with erosion debris that originated in the surrounding mountains. Most soils in the area are recent alluvial flood plain soils. They consist of unconsolidated deposits of clay, silt, and sand and occur as flood plain deposits.

Cache Creek Basin. The geology of the upper basin includes of the Franciscan formation, which forms the core of much of the

Coast Range (Corps 1993:2). Rock out-crops of this formation are found only in the upper basin and consist of marine sedimentary and volcanic rock. To the east of Clear Lake and in the central portion of the basin, rocks are predominantly of massive sandstone with imbedded conglomerates and silty shales. Continental deposits in the lower portion of the basin consist of silt-clay, sand, and gravel, and occur as discreet units and heterogenous mixtures. The younger overlying alluvium is similar and generally not as coarse as the continental deposits. Underground aquifers underlie the valley portion of the basin downstream from Rumsey. The size and extent of these aquifers are not known.

Willow Slough Basin. The geology of the basin consists mainly of deposits which are alluvium in nature (Corps 1993:4). Some rhyolitic tuff and sedimentary rock also exist in the middle of the basin.

Putah Creek Basin. The geology of the lower basin consists mostly of alluvium while the middle and upper elevations consist of marine sedimentary rock similar to the Cache Creek basin (Corps 1993:3).

Air Quality

Much of the study area lies within the Sacramento Valley Air Basin. Topographic boundaries, coupled with light winds and atmospheric stability, make the basin highly favorable for the accumulation of air pollutants. The typical summer circulation system allows transport of pollutants for long distances up and down the valley.

The major air pollution problems are high concentrations of oxidants and suspended particulate matter. Both pollutants frequently exceed air quality standards. The largest source of oxidants is motor vehicles. The major source of suspended particulates is agriculture.

The study area is included within the jurisdiction of the Yolo-Solano Air Pollution Control District. This agency operates several monitoring stations that measure ozone, carbon monoxide, suspended particulate matter, nitrogen dioxide, and sulphur dioxide.

Hydrology

Cache Creek Basin. The Cache Creek basin separates naturally into two hydrological areas: (1) Clear Lake and its tributaries and (2) the downstream Cache Creek area composed of

Cache Creek and its tributaries (FWS 1992a:2). Cache Creek drains approximately 1,300 square miles and trends in a northwest direction (Simons, Li & Associates, Inc. 1987:2.2). The major tributaries to Cache Creek are Clear Lake, North Fork Cache Creek, and Bear Creek. Numerous minor tributaries also join Cache Creek as it flows towards its confluence with the Yolo Bypass.

Below Clear Lake, Cache Creek descends through the rugged, 30-mile-long Cache Creek Canyon (Corps 1975:1). North Fork Cache Creek and Bear Creek enter the main stream about 9 and 24 miles, respectively, downstream. Cache Creek emerges from the canyon and flows south to Capay Dam, about 46 miles below Clear Lake. From Capay Dam, Cache Creek flows east through Capay Valley and, during the wet season, flows in a meandering pattern through the productive agricultural lands of Yolo County and into the Yolo Bypass. Prior to discharging into the Yolo Bypass, a portion of the heavy sediment load in Cache Creek is deposited in the Cache Creek Settling Basin at the mouth of the creek.

Willow Slough Basin. The Willow Slough basin drains approximately 200 square miles (Corps 1993:3). It includes the drainage areas of Dry Slough, Lamb Valley Slough, Cottonwood Slough, and Union School Slough. Winters Canal transects the upper portions of the Willow Slough basin. Runoff from these sloughs, located west of the canal, flows through a culvert under the canal. A smaller amount of basin runoff west of the canal flows directly into the canal and is carried to the next slough or occasionally overtops the canal banks. Covell Drain includes the drainages of the North Davis Drain and a major portion of the City of Davis. Willow Slough and Covell Drain drain into the Willow Slough Bypass, which is a feature of the Sacramento River Flood Control Project. The east Davis watershed is located just to the east of the Covell Drain and the City. This area drains directly into the Yolo Bypass.

Putah Creek Basin. Putah Creek originates in the upper Putah Creek basin and flows in a southeast direction to Lake Berryessa, exits Monticello Dam, and continues east through the irrigation dam at Lake Solano (Corps 1993:3). Water is diverted south to the Solano Water District while Putah Creek continues east to the South Fork and eventually into the Yolo Bypass. According to the Solano Irrigation District, the capacity of the diversion channel is 1000 cubic feet per second.

Water Quality

The overall water quality of the Sacramento River and tributaries is generally good, but the quality varies at specific sites due to the effects of geologic conditions, variable stream

flows and the quantity of local waste discharges and irrigation return flows. Higher sediment loads and extensive irrigated agriculture tend to degrade water quality. During the spring and fall, irrigation tailwaters are discharged into the drainage canals. In the winter, runoff flows over these same areas. In both cases, flows are highly turbid and introduce herbicides and pesticides into the drainage canals.

In addition, there is local concern about the high levels of boron and salts in Cache Creek. The hot springs in the Bear Valley drainage area naturally produce these chemicals, and runoff carries them into Cache Creek. When flows decrease in the late spring, the boron and salts precipitate out on the rocks along the creek. When the fall rainy season starts, higher flows redissolve the accumulated chemical deposits, and they are carried into the Yolo Bypass and eventually the Delta.

The Yolo County Flood Control and Water Conservation District regularly monitors the concentrations of boron and salts and does not use Cache Creek water to fill their 150 miles of ditches until the water is almost free of the chemicals. High concentrations can kill English walnut trees, as well as degrade water quality downstream.

Noise

Noise is often defined simply as unwanted sound, and noise levels and impacts are interpreted in relation to noise standards for each county. Existing dominant noise sources in the study area range from birdsong and wind to roadway and railroad activities. Noise levels near existing communities are typical of low-density urban areas and are primarily traffic related.

Socioeconomic Conditions

Most of the study area is located in Yolo County, but also extends into the southwestern portion of Colusa County and the northeastern portion of Solano County. The area is primarily rural and sparsely populated. The largest urban centers in the study area are the cities of Davis and Woodland. Yolo County has a population of 149,200, Colusa County 17,000, and Solano County 364,700 (California State Department of Finance 1992:14, 18).

Agriculture is an important source of employment and tax revenue for both Yolo and Colusa Counties (California Employment Development Department 1992a:15 and 16). In 1991, per capita personal incomes for Yolo County was $19,320, for Colusa County $18,803, and for Solano County $17,667. These were below the State average of $20,689, although not below the State poverty

level (California State Department of Finance 1992).

Public services in the study area are provided by the counties and their cities. Services include schools, libraries, roads, utilities, and emergency services. The major transportation routes are Interstates 5, 80, and 505, and State Highways 16, 20, 45, and 113.

The populations of the counties in the study area are expected to continue to grow at a higher rate than the State and will be primarily due to the influx of people who work in Sacramento and the Bay Area. Since the counties are attempting to preserve agricultural land, future development is planned adjacent to existing urban areas. County plans include additional housing, schools, water systems, and other public facilities. This future growth will occur with or without a Federally sponsored flood control project.

Land Use

Urban centers include, the cities of Davis and Woodland, west of the Yolo Bypass, and Winters, north of Putah Creek. There are also several unincorporated towns in the study area. These urban areas include residential, commercial, and industrial development. Other developments include the Yolo County Landfill and the City of Davis Water Pollution Control Plant, both located north of Willow Slough Bypass; Deganawidah Quetzacoatl University, located southwest of Willow Slough; the Department of the Air Force's Davis Transmitter Site, a small military installation located south of South Fork Putah Creek, and the Yolo County Housing Authority's Davis Migrant Center, a migrant farm worker housing complex, also located south of South Fork Putah Creek.

Agriculture is the predominant land use in the study area. The Farmland Conversion Report prepared by the California Department of Conservation, dated June 1992 and reprinted in October 1992, is maintained to provide land use conversion information to be used for future planning. Three major mapping categories are used: important farmland, interim farmland, and land committed to nonagricultural use. Counties in the important farmland category have modern soil survey information while counties in the interim farmland category use an interim mapping methodology until modern soil surveying techniques become available. Yolo and Solano Counties are categorized as Important Farmland, and Colusa County is categorized as Interim Farmland (California Department of Conservation 1992: 45, 51, 54).

Cache Creek between the Capay Bridge and town of Yolo provides high quality aggregate material, which has been mined

since the early 1900's. The aggregate has been used primarily by Yolo and Solano Counties as construction material for roads, rail beds, and concrete structures. Currently, there are six active aggregate mining extraction and processing operations in the study area. These operations include Syar Industries, Inc., Solano Concrete Company, Inc., Teichert Aggregates (two operations), Schwarzgruber & Sons, Inc., and Granite Construction Company. In addition, Cache Creek Aggregates has applied for a permit to mine and process gravel just downstream of Capay Bridge. The final EIS for this new operation has been certified by the County, but the permit has not been granted. These companies vary in size, activities, and output. Most own part of their land and have agreements with landowners to mine the rest. Gravel extraction occurs both at in-channel and off-channel locations. Facilities include sand and gravel processing plants, asphalt-concrete hot mix plants, concrete batch plants, material stockpiles, settling ponds, water wells, stationary and mobile equipment, and haul roads.

Recreation

Most developed recreational areas in the study area are found near Davis and Woodland. In addition, Cache Creek Canyon Regional Park, which offers picnicking, fishing, swimming, and camping is located on State Highway 16. Putah Creek Park, located 7 miles west of Winters, offers canoeing, fishing, and swimming. No developed recreational areas exist along the westside tributaries. However, they are regularly used by the public for recreational activities.

Hazardous, Toxic, and Radiological Waste (HTRW) Sites

To determine the extent of known HTRW sites located in the study area, Federal, State, and local lists were identified and reviewed. The Federal Environmental Protection Agency (EPA) maintains and updates the Federal "National Priorities List" for uncontrolled hazardous waste sites as required by the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). The latest list published in the Federal Register was updated September 25, 1991. The State EPA publishes the California Environmental Substance Sites List (AB 3750 list) for the state. The State Water Resources Control Board (SWRCB), California Integrated Waste Management Board, and Department of Toxic Substance Control contribute data to this list, which was last published on November 2, 1992. The Yolo County Health Services Agency maintains and updates the Hazardous Materials Site and Underground Tank Files, which lists the local HTRW sites.

A review of literature was conducted in order to identify HTRW sites located in the study area which could require special considerations for study work. Federal lists show no superfund sites in the study area. The nearest site on the Federal list is the Sulphur Bank Mercury Mine west of Cache Creek near Clearlake Oaks. State lists show a number of sites mainly in Davis and Woodland. Most of the sites listed by the State and Yolo County involve minor tank leaks, particularly around the larger cities of Davis and Woodland. There are also several open hazardous materials sites which would have to be evaluated if it is determined that they could be affected by project features. These sites are listed in Table 2.

A updated literature survey and field reconnaissance of the study area would be conducted during advanced studies to determine if there are any unlisted HTRW sites in the project area.

Table 2. Hazardous Materials Sites[1] (Open County Files[2])

Town	Location[3]	Substance	Notes
Esparto	Rumero Facility 26443 Woodland Ave.	Waste Oil	Open waste oil drum on vacant lot overflowed onto ground; owner ordered to clean up, agreed to do so by 1/92
Madison	Hernandez Trucking CR89 1/4 mile south of Hwy 16	Petroleum	Surface solid contaminated, excavated soils stockpiles & bioremediated; remediation initiated
Madison	Yolo County Housing Authority Hwy 16	Waste Oil	Removal of asphalt pad for vehicle changes showed contamination, assessment to be conducted
Rumsey	McLaughlin Mine NW corner of county	Mine Wastes	Waste discharge permit for open pit gold mine operation requires monitoring for arsenic, cyanide, and mercury
Winters	Mariani Nut Company 709 Dutton Street	Chlorine	Oil reported in gutter, crystallized substance found, inconclusive of chlorine test
Yolo	CR 97B	Asbestos & Agricultural Chemicals	Special investigation[2]

[1] This list excludes sites in Davis and Woodland because there are a number of different types of sites which will need to be closely evaluated if it is determined that project features could affect these sites.

[2] Open files indicates that the hazard is currently being evaluated.

[3] All sites are within Yolo County.

[4] Source: Department of Environmental Health Services, Yolo County, Reports Listing Hazardous Materials Files, August 1993.

KEY RESOURCES
HISTORIC AND EXISTING CONDITIONS

This section focuses on key resources in the study area that could experience potentially significant impacts as the result of flood control or environmental restoration work. Descriptions of historic conditions are confined to lower Cache Creek, and are provided to inform the environmental restoration analysis.

VEGETATION

Historic Conditions

As late as the mid 1800's, Cache Creek had an extensive and densely vegetated riparian zone (Dames & Moore 1991:3-75). Riparian forest and woodland occurred for a width of 3 to 4 miles on either side of Cache Creek from upstream of Capay to its confluence with the Sacramento River. Emergent and permanent marshes probably also followed most of the creek (Zentner & Zentner 1993:9,19). The species composition of that historic riparian forest probably included fremont cottonwood, willows, white alder, box elder, and elderberry, as well as upland species such as valley oak and Hind's black walnut (Dames & Moore 1991:3-75). Beyond the riparian forest stretched extensive grassland and valley oak woodland which were probably embedded with seasonal water channels, and depressions containing vernal pools, seasonal and permanent wetlands, and wet meadows (Zentner & Zentner 1993:9,19).

Existing Conditions

Cache Creek. Vegetation in the upper reaches of Cache Creek consists mainly of dense chaparral dominated by chamise, manzanita, and scrub oak probably. Oak and digger pine woodland occur on many of the lower slopes. Where the creek flows through wider valleys, surrounding land is mainly in agriculture.

Lower Cache Creek is dry part of the year primarily as a result of a diversion dam constructed near Capay in 1912 and subsequent irrigation diversions. Despite restricted water availability, some riparian vegetation still occupies the banks and terraces of the low flow channel (Corps 1993:135). This vegetation generally occurs in narrow strips, between 37 to 75 feet wide, along both sides of the low flow channel (FWS 1994:8). The riparian canopy consists of willow, sycamore, fremont and black cottonwoods, valley oak, and interior live oak trees. Many of the trees are draped with blackberry and grape vines. California blackberry, western ragweed, sweet anise,

curly dock, cocklebur, several species of thistles, grasses, and forbs make up much of the ground cover (FWS 1992a:6). The extent of this riparian vegetation is limited by nearby agricultural activity. Downstream from the town of Yolo, levees confine the creek within defined banks where riparian vegetation has become established. Wild rose, tamarisk, sandbar willow, elderberry, wild grape, and cottonwood are found on and between these levees. (Additional details on existing resources, potential impacts, and mitigation measures are included in Appendix A.)

Gravel Mining Reach. This reach extends for about 14.5 miles from the Capay Bridge downstream to about Yolo (Dames & Moore 1991:i). This area has been the site of gravel extraction since at least the 1930s (Environ 1980). Vegetation in the abandoned gravel pits is typically sparse, with small patches of dense shrubbery. Most of the area is covered by annual grasses and spring flowering annual forbs. Emergent wetlands occupy some depressions, canals, and drainage ditches. Typical wetland vegetation includes cattails, bulrushes, and willows.

Willow Slough Basin. The dominant vegetation along Willow Slough and Willow Slough Bypass is field crops and ruderal herbaceous plants. However, while riparian forest has been removed from most of the area, a narrow band of mature trees remains on portions of Willow Slough and Dry Slough (J&S 1990:3-8). Willow Slough also supports several of the largest continuous stands of riparian valley oak in the county (J&S 1990:3-8; Corps 1993:3).

Putah Creek Basin. The vegetation in this basin includes moderately heavy coniferous forests at the higher elevations, a mixture of deciduous trees and brush at intermediate elevations, and vineyards, orchards, and field crops on the valley floor (Corps 1993:3). The south levee of South Fork Putah Creek is generally devoid of woody vegetation. However, riparian forest does extend along parts of south fork Putah Creek. This forest is highly valued by resource agencies and local citizens. There is active interest in improving the quality and extent of the riparian corridor along this creek.

WILDLIFE

Historic Conditions

Cache Creek once supported a diverse wildlife community. Losses of wetlands, riparian forests, valley oak woodlands, and grasslands have substantially reduced the numbers of most wildlife species that historically occurred in the region (Jones

and Stokes 1994:2-16). Large animals, including grizzly bear, pronghorn antelope, and tule elk, have been largely extirpated from this region. Fur trapping was common in the early to mid-1800s, indicating a relative abundance of furbearing species, such as muskrat, raccoon, and possibly beaver (Dames & Moore 1991:3-75). Emergent marshes along lower Cache Creek once probably supported nesting populations of tricolored, red-winged, and yellow-headed blackbirds; white-faced ibis; herons; and egrets. Marsh wrens, American bitterns, soras, and Virginia rails probably also visited these wetlands.

Existing Conditions

Wildlife presence in the area is strongly correlated the type of vegetative habitat available for food, cover, and nesting. Along the westside tributaries, riparian forests and woodlands provide the greatest and most diverse resources for wildlife. Riparian corridors support such native mammals as Audubon cotton tail, brush rabbit, blacktail hare, gray squirrel, red and gray foxes, bobcat, raccoon, opossum, mink, weasel, striped and spotted skunks, badger, muskrat, river otter, and beaver. (Additional details of the fish and wildlife species are included in Appendix B.)

The Sacramento River system, including portions of the westside tributaries, is part of the Pacific Flyway and provides important resting and feeding areas for migratory waterfowl, shorebirds, and other water-associated birds. Water birds frequenting the area include common merganser, mallard, herons, egrets, kingfisher, and marsh wren. Other birds common to the study area include California quail, ring-necked pheasant, mourning dove, song sparrow, various owls, woodpeckers, red-tailed hawk, and Swainson's hawk. The continued destruction of wetlands in California has caused a shortage of wintering habitat relative to the breeding habitat in northern portions of the continent so that wintering habitat may be limiting to some Pacific Flyway populations.

Amphibians and reptiles inhabiting the study area include gopher snakes, western fence lizards, garter snakes, western pond turtles, and Pacific tree frogs. A variety of aquatic and terrestrial invertebrates are also found in the study area.

Cache Creek Basin. Although most of Cache Creek basin's historic habitat has been replaced by agriculture and urbanization, Cache Creek and its tributaries still support a variety of wildlife (FWSa 1992:7). Upland game species include California quail, ring-necked pheasant, mourning dove, band-tailed pigeon, Audubon cottontail, brush rabbit, black-tailed jackrabbit, and gray squirrel. Furbearers are represented by

coyote, red and grey foxes, bobcat, raccoon, Virginia opossum, spotted and striped skunks, badger, muskrat, weasel, and beaver.

Lower Cache Creek is within the Pacific Flyway used by 10-12 million ducks and geese of which 300,000 winter in the Yolo Bypass (which includes the Cache Creek Settling Basin). Many species of waterfowl frequent the basin. Dabbling ducks such as pintail, teal, and shoveler can be found on an intermittent basis during migration and wintering periods (FWS 1992a:7). Raptors include golden eagle, northern harrier, red-tailed hawk, short-eared and barn owls, and turkey vulture. Passerine species include the Brewer's blackbird, Lewis's woodpecker, acorn woodpecker, scrub jay, red-shafted flicker, common crow, yellow-billed magpie, and tree, rough-winged and cliff swallows. About 200 species of birds are known to be resident or seasonal visitors to the riparian community.

Gravel Mining Reach. The abandoned gravel pits in this reach provide relatively poor wildlife habitat. Vegetation is scarce and there is little cover. Reptiles and rodents are probably the most abundant resident species. Irrigated agricultural fields and patches of riparian vegetation occur adjacent to many of these pits. Wildlife expected to visit the abandoned pits include, jackrabbits, ground squirrels, and other small mammals; pheasants, valley quail, mourning dove, and songbirds.

Willow Slough Basin. Willow Slough Bypass provides low value habitat and wildlife in this area is restricted to those species typically found in Sacramento Valley agricultural settings. Resident and migrating birds may forage in the area, and small animals may inhabit the Bypass or margins adjacent agricultural fields. In contrast to the rest of Willow Slough and Willow Slough Bypass, the abandoned Willow Slough channel supports some of the largest continuous stands of riparian valley oak in Yolo County. This stand is home to large populations of Swainson's hawks as well as other species of special concern (Jones and Stokes 1990; Stallman 1992:66).

Putah Creek Basin. Putah Creek's wetland and riparian habitats are regularly used by a wide variety of birds, mammals, reptiles, and other wildlife. In the Putah Creek Campus Preserve, 34 mammal species have been observed (FWS 1991c).

FISH

Historic Conditions

Historic fish populations on Cache Creek included anadromous species, such as Pacific lamprey, chinook (king) salmon, and steelhead trout (Dames & Moore 1991:3-76; Stallman 1992:50).

Existing Conditions

The westside tributaries to the Yolo Bypass are part of the Sacramento-San Joaquin drainage system. This system contains the largest number of fish species of any drainage in California. There are 132 species of fish known to inhabit the waters of California (Moyle 1976:3). Sixty-nine percent (91) of these are known to occur in the Sacramento-San Joaquin drainage system, including 17 endemic species, 40 native resident or anadromous species, 15 native marine euryhaline species, and 36 introduced species. Table 3 lists some of the fish and general hydrologic conditions in the westside tributaries.

Environmental factors that limit the distribution of a fish species include temperature, stream gradient and flow, dissolved oxygen, water chemistry, salinity, depth, cover, bottom type, barriers to movement, seasonal changes, presence of other fish species, invertebrate populations, and aquatic plant abundance (Moyle 1976:24). Pollution, dams, dewatering of streams, canals connecting previously separated systems, and introduction of exotic fishes, invertebrates, and plants have also become important determinants of fish distribution. Optimal habitat requirements often change as a species passes from one stage of its life history to the next (Moyle 1976:24).

Cache Creek Basin. Conditions on Cache Creek have changed dramatically since modern historic times as a result of water supply (agriculture) and flood control projects. Downstream of the town of Capay, Cache Creek becomes an intermittent stream that is dry during most of the summer. The predominant species found in the creek are members of the minnow family and include squawfish, carp, and roach. Some other warmwater fish, such as bigscale logperch, have also been found in the warm summer pools of the intermittent sections of Cache Creek (Moyle 1976:324). And warmwater sport fish such as catfish and largemouth bass are also present. Anadromous fish rarely make their way into Cache Creek.

Gravel Mining Reach. Some warm water fish may occur in isolated pools and irrigation canals in the vicinity of the abandoned gravel pits.

Table 3. Fish Species and Hydrologic Conditions of the Westside Tributaries to the Yolo Bypass.

Name	Hydrologic Conditions	Fish Species	Comment
Cache Creek	Perennial but greatly reduced summer flows due to diversions upstream	hitch, squawfish, Sacramento blackfish, Sacramento sucker, bluegill, carp, green sunfish, white catfish, mosquitofish, goldfish, brown bulhead, channel catfish, roach, largemouth bass, smallmouth bass	Potential enhancement opportunities for fisheries
South Fork of Willow Slough	Naturally intermittent in upper reaches but supplied with irrigation water from Cache Creek	goldfish, carp, mosquitofish, white catfish, channel catfish, striped bass	Channelized so limited fishery value
South Fork of Putah Creek	Perennial to intermittent depending on seasonal rainfall below Putah Creek Diversion Dam (Lake Solano)	green sunfish, bluegill, Sacramento blackfish, Sacramento squawfish, carp, goldfish, Sacramento sucker, bigscale logperch, American shad, threadfin shad, fathead minnow, white catfish, brown bullhead, golden shinner, mosquitofish, chinook salmon, striped bass, largemouth bass, channel catfish, Mississippi silverside, redear sunfish, hitch	Excellent opportunity for fishery enhancement

Source: FWS 1980

From: FWS 1992a:29

Willow Slough Basin. The fish inhabiting the Willow Slough system are generally unknown but can be expected to be limited to species adapted to turbid, warmwater conditions. Such species include carp, goldfish, mosquitofish, white and channel catfish, and green sunfish.

Putah Creek Basin. Despite its variable flows, lower Putah Creek supports a variety of fish (FWS 1992a:27). Twenty-nine native and exotic fish species have been observed in Putah Creek at the Putah Creek Campus Preserve (Jones & Stokes 1994:3-44). Resident nongame fish include the Sacramento sucker, Sacramento squawfish, carp, inland silverside, and mosquitofish (Jones & Stokes 1994:3-45). Relatively common warmwater gamefish include largemouth bass black-and-white crappie, bluegill, sunfish, catfish, and bullhead (FWS 1991). During wet periods, Putah Creek supports three anadromous species - Pacific lamprey, chinook salmon, and steelhead - which enter the creek via the Yolo Bypass (FWS 1992a:28).

RARE, THREATENED, AND ENDANGERED SPECIES

Historic Conditions

Extensive riparian forests once lined lower Cache Creek providing habitat to many riparian dependent animals, including several birds that are now sensitive, endangered, or extirpated from the region. Those species may have included the western yellow-billed cuckoo, willow flycatcher, and least Bell's vireo (Dames & Moore 1991:3-76).

Existing Conditions

In a letter dated October 26, 1993, the FWS identified 23 special status species as possibly occurring in the study area. These include: 4 Federally listed species, no species proposed for listing, 18 candidate species, and 1 species recommended for candidate status (see Appendix C). The Federally-listed species are the endangered bald eagle and palmate-bracted bird's-beak, and the threatened giant garter snake and valley elderberry longhorn beetle. Candidate species identified by the FWS are: category 2 candidates Sacramento splittail, california tiger salamander, foothill yellow-legged frog, northwestern pond turtle, tricolored blackbird, mountain plover, loggerhead shrike, Pacific western big-eared bat, greater western mastiff-bat, San Joaquin Valley woodrat, recurved larkspur, adobe lily, Brewer's dwarf-flax, California hibiscus, Hinds' walnut, few-flowered navarretia, and Gairdner's yampah; category 1 candidate Contra Costa goldfields; and category 2 recommended candidate western spadefoot toad. Candidate species have no protection under the

Endangered Species Act, but are included for consideration since it is possible that one or more of these candidates could be proposed and listed in the future. In addition, a FWS biologist observed ferruginous hawk along lower Cache Creek while on a field visit in February 1994. More detailed information on listed species are provided in the U.S. Fish and Wildlife Service's (FWS) Planning Aid Report (1994:14-15) which is provided as Appendix A.

In a letter dated October 7, 1993, the National Marine Fisheries Service reported that the Federally listed threatened winter-run chinook salmon may occur seasonally in the study area, even though the study area is located outside the designated critical habitat for winter-run chinook salmon (see Appendix C).

The State recognizes as endangered, threatened, or rare, four species which may occur in the study area; Swainson's hawk, bank swallow, giant garter snake, and western yellow billed cuckoo.

Cache Creek. A search of the California Natural Diversity Data Base (NDDB 1993) for records of special status species occurrence along lower Cache Creek, in the vicinity of the flood control alternative plans, identified records for 8 species within 5 miles of the creek. Half of these (4) have also been reported within 1 mile of the creek (Swainson's hawk, bank swallow, Ferris' bird's-beak, western yellow billed cuckoo). Results of a California Natural Diversity Data Base (NDDB) search are shown in Table 4 and Appendix D. It should be noted that many of the candidate species identified by the FWS have not yet been added to the NDDB.

Willow Slough Basin. Swainson's hawk is known to use remnant oak woodlands that occur in the old Willow Slough channel. Giant garter snake occurs in Willow Slough Bypass.

Putah Creek Basin. The riparian forests along Putah Creek support the highest nesting populations of Swainson's hawks in California (Jones & Stokes 1990). Many special status species occur along Putah Creek, including cormorant, osprey, sharp-shinned hawk, Coopers hawk, long-eared owl, and Valley Elderberry Longhorn Beetle (Jones & Stokes 1990; Stallman 1992:35).

Table 4 Threatened, Endangered, and Other Species of Concern in the Westside Tributaries to Yolo Bypass Study Area or Vicinity.

Common Name	Federal Listing	State Listing	Project Area Location[1]	Project Vicinity Location[2]
White Faced Ibis	Candidate 2	None	no records	Grays Bend 10N 02E 23SW QT
Swainson's Hawk	None	Threatened	Grays Bend 10N 02E 04XX QT 10N 02E 03NE QT Woodland 10N 02E 08SE QT 10N 02E 06NW QT 10N 02E 05NW QT 10N 02E 04SW QT 10N 02E 04SW QT 10N 01E 23SW QT 10N 01E 35SW QT 10N 01E 02SE QT 10N 01E 13NE QT 10N 01E 11NE QT 10N 01E 15NW QT 10N 01E 14SW QT	Grays Bend 09N 02E 03NW QT 09N 02E 03SE QT 11N 02E 35SE QT 10N 03E 06NW QT 11N 03E 31SE QT Woodland 09N 02E 08NE QT 09N 01E 01NE QT 09N 02E 08SE QT Madison 09N 01E 21NE QT
Western Snowy Plover	Threatened	None	no records	Grays Bend 10N 02E 22XX QT
Bank Swallow	Threatened	None	Madison 10N 01E UNXX QT	Madison 10N 01W 2NW QT 10N 01W 23SW QT
Tricolored Blackbird	Category 2	None	Listed by U.S. Fish and Wildlife Service in Endangered Species List.	Grays Bend 10N 02E 23XX QT 10N 03E UNXX QT 09N 02E 12XX QT
Valley Oak Woodland	None	None	Woodland 10N 02E UNXX QT	no records
San Joaquin Saltbush	Category 2	None	no records	Grays Bend 10N 02E 23NW QT 10N 02E 11NE QT
Ferris' Bird's-beak	Endangered	Endangered	Grays Bend 09N 02E 11NE QT 10N 02E 22SE QT	no records
Western Yellow Billed Cuckoo	None	Endangered	Grays Bend Woodland Madison	Grays Bend Woodland Madison

[1]In project area: Number of NDDB records within 1 mile of the boundaries of the Cache Creek sites.
[2]In project vicinity: Number of NDDB records within 5 miles of the boundaries of the Cache Creek sites.

CULTURAL RESOURCES

Historic Conditions

The prehistoric cultural pattern for the Sacramento area follows those established by research in the Delta Region. Occupation of the area began approximately 12,000 years ago. The pattern of archeological remains indicates a gradual shift in food processing and weapons technology to more sophisticated forms. As populations became more sedentary, they became dependent on staple foods (Chartkoff and Chartkoff, 1984; Moratto, 1984).

The study area is located in the ethnographic territory of the Patwin. The Patwin used languages belonging to the Penutian linguistic family and were also linguistically considered Southern Wintuan. They occupied a region north of Suisun Bay to above Colusa that encompassed the Cache and Putah Creek drainages (Wilson and Towne, 1978; Johnson, 1978).

The historic period began with Spanish exploration of the area along the Sacramento and American Rivers. Fur trappers were active along area rivers, beginning with Jedediah Smith in 1827 (Beck and Haase, 1974; Beck and Williams, 1972, McGowan, 1961; Morgan, 1964). Settlement did not begin until John Sutter arrived near the confluence of the American and Sacramento Rivers in 1839. Eventually, many people settled in the study area and established farms and ranches. Although initially protected by natural levees, these fields were susceptible to flooding during high flows. Farmers, in cooperation with local and state governments, began to construct series of levees along the Sacramento River. Intervention by the state government during the Progressive Era (1906-1920) led to the creation of centralized control over reclamation and flood control in California (Hoover et al., 1990; Bean, 1968; Kelley, 1989).

Existing Conditions

Archival research for this historical overview was conducted at the following locations: California Room, California State Library; Bureau of Land Management, Sacramento; Sacramento District Library, Corps; and Sacramento Library, California State University. A records check for previously known cultural resources sites in the vicinity of the flood control alternatives and the gravel mining restoration alternative was requested from the Northwest Information Center, Sonoma State University. The results of this records check are provided below. Note that, to

date, no effort has been expended to identify cultural resources upstream of Capay Dam or downstream of the entrance to Cache Creek Settling Basin.

Flood Control Alternative Plans

Alternative 1. The no-action alternative establishes the base condition for the project. The records check reported 17 archeological surveys for the entire study area. Fourteen archeological sites have been recorded, one with historic aspects. The Information Center also provided historic site forms for 32 buildings and structures in the study area.

Alternative 2. The Information Center reported two archeological surveys for the area included in this alternative. Two prehistoric sites, CA-Yol-135 and CA-Yol-71, are within the boundaries of this alternative. In addition, the two bridges considered for replacement would need to be evaluated for their significance.

Alternative 3. The records check for this alternative revealed the same information as for Alternative 2.

No sites within the study area are listed on or eligible for the National Register of Historic Places. The Yolo Branch Library in Yolo and the Nelson Ranch in the vicinity of Woodland, both on the National Register, are within a half mile of the study area. No California State Historical Landmarks are located within the study area.

Environmental Restoration Alternative Plans

Alternative 1. Base condition information for the restoration no action alternative is the same as for flood control alternative 1.

Alternative 2. Two surveys were reported for this alternative, covering 10 of the 13 restoration sites. No sites were reported for the 10 sites previously surveyed. Two historic sites, Yol-HRI-5/154 (the 1856 Moore Ditch) and Yol-HRI-4/109 (an 1972 house), are within a half mile of two of the restoration areas.

Alternative 3. A plan to restore historic fisheries to Cache Creek is being considered. however, the features of this plan have not been finalized, making a review of existing information on cultural resources difficult. Further literature review for known cultural resources would be conducted after

finalization of this plan. Known sites along Cache Creek below Capay Dam that could be affected by this alternative are described above.

KEY RESOURCES
FLOOD CONTROL AND RESTORATION IMPACTS

The no action alternatives (Alternative 1) for both the flood control and the environmental restoration plans are combined into a single discussion, and presented in sections titled, "No Action Alternative for Flood Control and Restoration Plans." Also, while not evaluated in detail in this document, it should be anticipated that construction could also result in short term impacts to air quality, water quality, and noise.

VEGETATION

No Action Alternative for Flood Control and Restoration Plans

Lower Cache Creek. Under the no action alternative, overall vegetation composition in and along Cache Creek would generally not be expected to change significantly from existing conditions. Vegetation, in particular riparian forest and woodland, may experience continued decline in distribution and vigor as a result of human activities. Potentially detrimental human activities include: gravel mining, offroad vehicle use, groundwater pumping for irrigation, native vegetation removal, restricted instream flows, and land-use changes. In addition, exotic species are spreading.

The land-use change which could most profoundly influence the biological conditions in the project area would be conversion of lands in agricultural production to residential or non-agricultural business uses, in response to increasing human population in the area. Such conversion would have a detrimental effect on the ability of the area to support natural plants and animals. Without the proposed project, construction within the existing Cache Creek flood plain would be expected to be slow, however, if local agencies follow existing Federal guidelines to avoid such construction. Less marked changes in the natural communities in the project area could result if farming techniques and/or cropping patterns change, but the type and magnitude of such changes cannot be predicted at this time.

Introduced species, such as tamarisk and giant reed, would probably continue to dominate parts of the riparian zone along Cache Creek. These two species thrive in riparian areas which

are disturbed, whether by natural events (e.g., flood scouring, channel migration, and sedimentation) or by human activities (e.g., earth-moving or other construction along channels and vegetation removal) (Rieger and Kreager 1989).

Abandoned Gravel Pits. Vegetation in and adjacent to the abandoned gravel pits would not be expected to change significantly from current conditions. Succession would proceed, however, due largely to harsh site conditions resulting from mining activities, this process would be expected to proceed relatively slowly. Hardy pioneer species, primarily annual grasses and forbs, would probably dominate most of the area for years to come. Emergent wetland vegetation existing in depressions and canals would be expected to continue to exist as long as these areas are able to hold water during some portion of the year.

Flood Control Alternative Plans

Alternative 2. This alternative would affect a 16 mile reach of Cache Creek. Substantial impacts would result from about 14 bank-miles of new setback levees, 16 bank-miles of existing levees which would be raised, and 4 bank-miles of bank protection. About 240 acres would be affected by project construction and maintenance. Riparian vegetation would be removed from 50 acres and agricultural crops (including orchards) would be permanently removed from 120 acres and temporarily removed from 70 acres.

Setback Levees. Constructing these new levees would convert existing land uses to lower quality habitat. The lost habitat would be predominantly agricultural, with smaller amounts of ruderal, riparian scrub, and oak woodland. Such losses in habitat value would require mitigation. Should the construction of setback levees result in decreased vegetation management in the stream channel, the amount and value of riparian or wetland habitats between the old levee and the new setback levee might increase. This change would benefit the natural ecosystem. Most of this potentially affected area is currently in low-to-medium value (to fish and wildlife) agriculture, including row crops, walnut orchards, and grain crops. The land use and habitat values of some of these lands would likely change with the construction of setback levees. The impact on these lands is difficult to predict. Another effect of setback levees is that land between the setback levees and the stream may flood more frequently, assuming that existing levees are not maintained in areas where setback levees are constructed.

Slope Protection. Two long-term impacts of slope protection are (1) the elimination of riparian vegetation from

the protected bank and (2) the halting of the natural meandering movement of the stream channel, accompanied by deposition and bank-cutting. The loss of riparian habitat is almost total and unavoidable when slope protection is used. Less obvious is the loss of cut banks, which are used as nesting habitat by some birds (e.g., belted kingfishers and bank swallows), both of which occur in the region. Last, the natural process of stream channel movement produces a matrix of vegetation zones of different ages in the riparian habitat. This matrix is more complex and diverse than a stabilized bank. Slope protection would have the greatest effect, reducing or eliminating about 4 bank-miles of riparian forest and scrub-shrub. Slope protection and associated maintenance regimes typically preclude the reestablishment of riparian vegetation, and habitat losses could mean significant mitigation needs.

Raise Levees. When the affected habitat on the slopes of the existing levees is ruderal, the loss of this habitat during levee raising would probably be temporary, until ruderal vegetation was reestablished. In this case mitigation would not be required. However, mitigation measures would be needed to offset any decreases in habitat value if riparian, agricultural, or unmanaged ruderal habitat are converted to levee slopes during construction of the levee footprint. Raising existing levees would affect about 16 bank-miles of riparian forest and scrub-shrub. These losses could be short or long term, depending on the extent of the zone affected by construction, nature of the disturbance, and levee maintenance schedules.

General Construction Impacts. These impacts generally are temporary, with little lasting impacts on biological resources. When impacts on particular species can be identified, e.g., on nesting Swainson's hawks, the scheduling or location of construction can often be adjusted to minimize impacts. For many species, however, the effects of disturbances are largely unknown.

Decreased Frequency of Flooding. Significant land-use changes may result from decreasing the frequency of flooding. For example, agricultural land may be converted to residential housing. The full impacts are often long term and may be subtle over the short term. This would be especially true in areas that would be protected from the larger 100- and 500-year flood events. Flooded areas provide transient habitat for wildlife such as waterfowl and wading birds. The proposed work would cause another small incremental decrease in flooding frequency in areas that already flood relatively rarely.

Alternative 3. This alternative would have a significant adverse impact on physical and biological resources along 10

miles of Cache Creek. About 402 acres of riparian vegetation would be affected. An additional 220 acres of grassland/upland with some scattered native oaks and introduced woody species (walnut), and 25 acres of agricultural land would be affected. Much of the impacts to riparian vegetation would result from the channelization and the 3 bank miles of bank protection. Impacts include degradation of riparian habitat in the channel and effects on the water table due to increased drainage. Channelization often leads to increased stream velocities, which increases rates of erosion and sediment transport downstream and causes further negative effects on near-stream habitats. Past studies indicate that channelization causes decreases in both fish and wildlife diversity and biomass.

The impacts of slope protection, raising existing levees, general construction, and reducing the flood plain are the same as those discussed under Alternative 2.

Restoration Alternatives Plans.

Alternative 2. Restoring the gravel pit areas to seasonal or permanent wetlands and associated riparian and upland plant communities would increase the diversity and complexity of vegetation composition and structure at the sites. The community would shift from a wash community to an integrated complex of aquatic-wetland-terrestrial communities. In the Central Valley, these complexes may be defined functionally as a single ecosystem.

The existing grasses, forbs, and scattered woody plants would change to open water, emergent wetland plants, surrounded by riparian trees and shrubs, and some oak woodland. This change would represent a beneficial environmental impact.

The wetland might also contribute to groundwater recharge. Increases in groundwater level could improve site conditions for riparian plants. If the additional groundwater is not removed for irrigation or other purposes, it may help slow land subsidence, a significant issue in the lower Cache Creek area.

Some adverse impacts to wetland vegetation could be experienced when renovating old irrigation canals for use as supply and distribution canals for the constructed wetlands.

Alternative 3. Information sufficient to evaluate potential environmental impacts from restoring fish populations to Cache Creek is not yet available. It would be reasonable to anticipate short term construction impacts to riparian, wetland, and other vegetation in the vicinity of project features (fish ladders and gates).

WILDLIFE

No Action Alternative for Flood Control and Restoration Plans

Lower Cache Creek. Under the no action alternative, wildlife habitat conditions in and along Cache Creek would generally be expected to remain unchanged. Therefore, the number, type, and distribution of wildlife species associated with the creek should remain relatively constant. Riparian habitat along the creek appears to be experiencing a slow decline in extent and quality. This habitat is particularly valuable to wildlife in the vicinity. Decreases in the amount and quality of riparian habitat could adversely affect wildlife populations.

Abandoned Gravel Pits. Under the no action alternative, wildlife in the abandoned gravel pits would be expected to remain as described in the existing conditions. Plant succession in the pits would probably occur very slowly and the area would continue to be of relatively low value to wildlife. Wildlife population growth in the gravel pit restoration areas would parallel the progression of vegetative growth in order to sustain increasing populations.

Flood Control Alternative Plans

Alternative 2. Impacts to wildlife cannot be estimated at this time. An indicator of project impacts to wildlife is impact to vegetation, which is a primary component of terrestrial wildlife habitat. Implementation of alternative 2 would seriously impact 51 acres of riparian habitat and 186 acres of agricultural habitat. Riparian habitat is very valuable to a wide variety of species and is relatively scarce in the region.

Alternative 3. This alternative would affect more wildlife habitat than Alternative 2: 402 acres of riparian habitat, 25 acres of agricultural habitat, and 220 acres of grassland/upland habitat.

Environmental Restoration Plans

Alternative 2. Negative environmental impacts to wildlife from gravel pit restoration should be minimal. Construction could temporarily disturb or displace small mammals, invertebrates, reptiles and amphibians, however, the gravel pit restoration would reestablish native vegetation that could significantly increase the number of individuals and species in the area by providing high quality marsh and woodland foraging

habitat. Various reptiles and amphibians are present in the irrigation canals and in Cache Creek, especially during the wet seasons. The use of existing irrigation canal systems to route winter and spring flows into the restored gravel pits should have no adverse impacts to wildlife. However, maintenance activities could affect birds, fish, invertebrates, amphibians and reptiles inhabiting the irrigation canals.

Gravel pit wetland restoration would provide many benefits to wildlife, including wintering waterfowl, and other wetland-dependent species.

Alternative 3. If properly designed and timed, activities associated with the restoration of historic fish resources to Cache Creek, such as the construction of seasonal or permanent wetlands and fish ladders, would have minimally impact wildlife. Some small populations of birds, amphibians, reptiles, invertebrates, and mammals could be temporarily displaced during fish ladder installation or seasonal/permanent wetlands construction.

FISH

No Action Alternative for Flood Control and Restoration Plans

Lower Cache Creek. Under the no action alternative, fish community composition and fish population sizes would remain relatively unchanged from current conditions. Warm water species would continue to dominate the aquatic community, and anadromous species would be virtually absent from the creek.

Abandoned Gravel Pits. With the possible exception of some abandoned canals and depressions, where some warm water species may occur, no fish habitat exists in the abandoned gravel pits. This condition would not change significantly in the foreseeable future.

Flood Control Alternative Plans

Alternative 2. The setback levee feature of this alternative plan would have relatively minor impact on fish and aquatic habitat. However, levee reconstruction and ripraping along levees, terraces, and, especially low flow channel banks, could significantly impact fish since aquatic and adjacent riparian habitat would be disrupted or destroyed.

Alternative 3. While fish communities in Cache Creek have been substantially altered since modern historic times, primarily as a result of flood control and water conservation practices

that alter and reduce flows in the creek, the remaining fish communities could be expected to experience significant adverse impacts from implementation of this alternative. Existing aquatic and adjacent riparian habitat within the project reach would experience complete and permanent degradation.

Environmental Restoration Alternative Plans

Alternative 2. Construction of seasonal and permanent wetlands in the abandoned gravel pits would provide feeding and spawning habitat for warm water fish, including hitch, squawfish, Sacramento blackfish, Sacramento sucker, bluegill, carp, green sunfish, white catfish, mosquitofish, goldfish, brown bulhead, channel catfish, roach, largemouth bass, smallmouth bass, and the Federal Candidate Sacramento Splittail. The permanent wetlands would be particularly valuable during the dry summer months.

Potential adverse impacts resulting from restoration efforts could include entrapment of fish in seasonal wetlands, and water quality impacts due to canal and wetland maintenance activities.

Alternative 3. This plan would attempt to restore native fish communities to Cache Creek by removing physical barriers to fish passage, thereby providing access to miles of habitat in the upper reaches of Cache Creek and its tributaries. Restoration features could include fish ladders at Capay Dam and low flow gates at the base of the Cache Creek Settling Basin.

Several critical factors must be considered during advanced development of this restoration plan. Design must include consideration of hydrology as it related to biological resources. The timing, duration, and amount of flows in Cache Creek must be identified and compared to the life cycle needs of target species, especially anadromous fish. If adequate flows are not present for both in-migrating and out-migrating fish, they may become trapped and perish. Fred Meyer, a fish biologist with the California Department of Fish and Game (pers. comm. 1994) has suggested that a perennial water supply would be required to reestablish anadromous fish in Cache Creek. In addition, a low flow channel could be needed.

Fred Meyer identified several other conditions that would need to be evaluated to insure successful passage of anadromous fish species in Cache Creek; seasonal temperature, dissolved oxygen concentration, turbidity, flows, pool riffle ratios, ease of movement through settling basin, predators, fish ladder design and location, and sediment load (pers. comm. 1994). In addition, it would be important to recognize that adult anadromous fish would not instinctively migrate up Cache Creek. Juvenile and adult brood stock would probably have to be reintroduced into

Cache Creek so they would be imprinted to the area and return there to spawn.

To fully develop an effective fish restoration plan for Cache Creek, the Corps would need to work in partnership with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, Department of Fish and Game, Department of Water Resources, and other interested agencies and organizations.

Construction and installation of fish ladders and low flow gates could produce temporary adverse impacts on existing fish and other aquatic resources.

RARE, THREATENED, AND ENDANGERED SPECIES

No Action Alternative for Flood Control and Restoration Plans

Lower Cache Creek and Abandoned Gravel Pits. It is not possible to predict the future status of rare, threatened, and endangered species on lower Cache Creek since the current status of these species has not been fully established as part of this EE. It is reasonable, however, to assume that Federally listed species identified by the FWS as possibly occurring in the study area would maintain their protected status into the foreseeable future. It is also likely that some of the species identified by the FWS as candidates for listing would be listed prior to completion of a major flood control project along lower Cache Creek.

Flood Control Alternative Plans

Alternatives 2 and 3. Potential impacts on rare, threatened, and endangered species cannot be fully evaluated at this time. Federal or State listed species probably occur on lower Cache Creek. It is possible that some of these species could be affected by construction activities. Detailed evaluation of potential impacts to listed species should be conducted during feasibility studies and coordinated with the FWS.

The giant garter snake may occur in canals, ditches, other waterways and adjacent uplands along lower Cache Creek. Surveys would be needed to determine the actual presence of the snake. The location and timing of construction would need to fully consider the giant garter snake in order to avoid impacts to the animal.

The FWS (1994) indicated that the VELB and its habitat are likely to occur on lower Cache Creek. Removal of elderberry

shrubs would reduce available habitat and could result in a negative impact on the beetle. This impact could either be the "take" of individual beetles or long-term reduction of beetle populations due to habitat loss. Elderberry shrubs generally occur on higher terrace banks of the riparian zone, and thus could be subject to adverse impacts due to any construction activity conducted above the stream bed.

Bald eagles would probably experience no significant adverse impact from project construction.

If palmate-bracted bird's-beak occurs along lower Cache Creek, construction activities could destroy this plant or degrade habitat conditions.

Trees, especially riparian stands, provide nesting habitat for Swainson's hawk. Removing such trees could reduce hawk nesting habitat. Also, construction activities conducted near active nests could disturb the hawks and result in nest abandonment. Guidelines developed by DFG for Swainson's hawk protection include establishing a one-half mile buffer zone around active nest sites. Construction activities in this zone are restricted from about March until September when the young are no longer vulnerable to disturbance.

Environmental Restoration Alternative Plans

Alternative 2. Constructing wetlands in the abandoned gravel pits could temporarily disturb any resident Federal or State listed animals, and could potentially destroy plants. However, the habitat in the abandoned pits is considered to be highly degraded and relatively undesirable wildlife habitat, so it is unlikely that listed species regularly inhabit these areas. The Federal endangered palmate-bracted bird's-beak is not expected to occur in the gravel pits since these pits were cleared of vegetation and the soils have bee highly disturbed by previous mining activities.

Restoration efforts would result in development of scarce high value wetland and associated riparian and upland habitats. This could benefit several listed or rare species, including: giant garter snake, California tiger salamander, western spadefoot toad, foothill yellow-legged frog, northwestern pond turtle, tricolored blackbird, and mountain plover. The seasonal and permanent wetland could also provide suitable habitat for reestablishment of palmate-bracted bird's beak.

Alternative 3. Construction and installation of fish ladders and low flow gates could benefit the threatened winter-

run chinook salmon and the candidate Sacramento splittail by providing access to upstream spawning habitat. Since the salmon and splittail are not expected to currently occur in Cache Creek, fish ladder and low flow gate construction and installation should produce no adverse impacts to these species. However, adverse impacts could occur if ladders and gates inhibit the movement of fish back into the Sacramento-San Joaquin Delta, or if quantity or timing of flows are insufficient for out migration. Coordination with DFG (McGee, pers. comm. 1994) indicated that DFG may prefer to maintain all salmon runs in the main stem of the Sacramento River and may consider restoring salmon to Cache Creek to be undesirable due to potential survival risks. Besides the issues mentioned, predation by warmwater fish would be a potential concern.

CULTURAL RESOURCES

No Action Alternative for Flood Control and Restoration Plans

Impacts to certain cultural resources would occur even without a flood control project. Continuing urban expansion and agricultural practices could destroy many prehistoric and historic sites. Natural processes such as erosion, root and rodent intrusion, flooding, and grazing could affect prehistoric sites. Vandalism, through deliberate looting and collecting, is a national problem and is expected to continue.

Flood Control Alternative Plans

Impacts to cultural resources are difficult to assess at this level of study because some of the potential project areas have not been subjected to intensive ground surveys. Based on available information, it is likely that the alternative plans would affect cultural resources.

Impacts to cultural resources from the flood control alternative plans could include, but are not limited to, destruction due to construction of levees, access roads, staging areas, procurement of borrow materials, or channel deepening or widening. The flood control alternative plans might include removal of railroad and highway bridges. These structures would need to be evaluated for the National Register of Historic Places if they are at least 50 years old, or of exceptional significance.

Environmental Restoration Alternative Plans

Alternative 2. Activities related to gravel pit restoration that could affect cultural resources include, but are not limited to: excavating wetlands, contouring land, digging irrigation systems, and planting vegetation. Since the gravel mining sites have already been substantially disturbed, the likelihood of encountering cultural resources is small.

Alternative 3. Several potential features of the fish restoration plan could affect cultural resources, including, constructing fish ladders, low-flow gates, and a low-flow channel.

MITIGATION AND ENHANCEMENT MEASURES

U.S. Fish and Wildlife Service Mitigation Planning Goals and Priorities

This section provides a general discussion of FWS planning goals for mitigation of impacts to specific habitat types. The information was taken from the draft Planning Aid Report (March 23, 1994) prepared by the FWS for the Westside Tributaries to Yolo Bypass Reconnaissance Study. Should this study proceed into the feasibility phase, impacts and mitigation would need to be assessed with a Habitat Evaluation Procedure (HEP) analysis.

Affected Habitat.

Riparian Forest, Riparian Shrub-Scrub, and Palustrine Emergent Wetlands. The highest value habitats along Cache Creek are riparian forest, riparian shrub-scrub, and emergent wetlands. The FWS classifies these habitat types as Resource Category 2 (see Table 5). Mitigation goals for this category is "no net loss of in-kind habitat value or acreage." In-kind replacement is defined as "to provide or manage substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate those lost."

To compensate for unavoidable category 2 habitat losses, an area (or areas) without these attributes and of sufficient size (as determined by the HEP) should be provided for management. Plantings of indigenous species would likely be required in the area(s) to provide habitat compensation values. In 1991, the estimated cost to create these habitat types averaged about $25,000 per acre, excluding land acquisition and maintenance costs. Irrigation would be required for a minimum of several

Table 5. U.S. Fish and Wildlife Mitigation Planning Goals

Habitat Type	Resource Category	Mitigation Planning Goals	Mitigation Requirements
Palustrine Emergent Marsh	2	No net loss of in-kind habitat value	In-kind replacement of lost habitat values
Riparian Forest and Riparian Scrub-Shrub	2	No net loss of in-kind habitat value	In-kind replacement of lost habitat values
Agricultural and Ruderal Habitats	3	No net loss of habitat value while minimizing loss of in-kind habitat value	Replacement of habitat value, but not necessarily in-kind value
Oak woodland	2	No net loss of in-kind habitat value	In-kind replacement of lost habitat values

years, depending on conditions, or until the plantings were well established and self-sustaining. Any dead or decayed trees and shrubs would need to be replaced and maintained until self-sufficient. A detailed mitigation monitoring study would be required. This plan would have to be developed jointly by the Corps, FWS, and California Department of Fish and Game once specific impacts and mitigation sites are identified. At a minimum the plan should identify specific attributes of the site that would be monitored, sampling procedures, and reporting requirements.

Oak Woodland. Isolated stands of oak woodland occur along Cache Creek. Oak woodland is a Resource Category 2 habitat. The FWS' mitigation goal is "no net loss of in-kind habitat value or acreage."

Ruderal and Agricultural Habitats. Ruderal (non-native grasses and forbs) and agricultural habitats also occur along Cache Creek. The FWS classifies ruderal and agricultural habitats as Resource Category 3. The mitigation goal for this category is "no net loss of habitat value while minimizing loss of in-kind habitat value." The FWS has suggested that the best way to mitigate for project-related losses of this habitat would be to enhance wetland habitat values. Some losses of ruderal

vegetation may be offset relatively quickly and easily by reseeding the disturbed areas with native grasses and forbs (FWS 1991).

Other. Scattered trees and shrubs lost due to project construction could require replacement at a ratio as high as 5:1 (FWS 1991). Due to lower soil moisture conditions, such plantings could require watering and maintenance for up to 6 years.

Affected Ecological Functions. Streams and the riparian vegetation associated with them are significant landscape features. They provide corridors for wildlife movement and critical linkages between diverse landscape elements (e.g. grassland foraging areas and wetland nesting areas, etc.). The FWS has recognized these functions as significant and has identified conservation of riparian habitat continuity as a mitigation goal. This would be accomplished by (1) full replacement of the linear aspects of any habitat lost along the creek, and (2) maintaining riparian habitat on at lest one bank of the creek throughout the project area.

Mitigation Locations. Where compensation is the identified mitigation measure, sites should be selected in the following order, from the most desirable to the least desirable: (1) within the project area along Cache Creek, (2) along Cache Creek outside the project area, and (3) outside of the Cache Creek drainage.

U.S. Fish and Wildlife Service Recommendations

Several of the FWS' recommendations emphasize the ecological significance of existing and future riparian vegetation in and along Cache Creek. The FWS provides additional mitigation and enhancement planning information in its draft Planning Aid Report (1994:23-27).

(1) Adopt the FWS' preferred alternative of setback levees. This would incorporate setback levees on both sides of Cache Creek, to the extent feasible, and would set levees far enough back to permit unlimited vegetation growth between levees and stream channel.

Corps Response: The setback levees in the setback levee alternative plan would allow for existing plant growth but would not accommodate unlimited future growth. Analysis to date indicates that cost is the major constraint to more extensive setback levees. Should this study enter feasibility phase, opportunities for environmentally responsive setback levees would be reviewed.

(2) Riparian habitat losses should be replaced on site with in-kind habitat. The continuous linear aspect of riparian habitat along the creek should also be maintained, and, where possible, enhanced.

Corps Response: Should the project proceed into the feasibility phase, planning efforts would attempt to first avoid and then minimize impacts to riparian habitat. If losses are unavoidable, riparian habitat would be replaced in-kind and on site where feasible.

(3) Mitigate for riparian habitat loss due to the project by managing the habitat between setback levees and stream channel as riparian and seasonal wetlands habitats. Incorporate, where feasible, construction of a secondary channel between the existing channel and setback levees.

Corps Response: We appreciate this innovative mitigation suggestion. The feasibility of implementing such a plan would be considered further during the feasibility phase.

(4) Fund the FWS for biological surveys of the project area, should the Corps choose an alternative other than the FWS' preferred alternative. This is because other alternatives could have a significantly greater biological impact, whose assessment would require a more detailed knowledge of the area's resources.

Corps Response: We appreciate being advised that additional biological surveys could be needed should the Corps proceed with one of the flood control alternative plans. During feasibility phase, the Corps would coordinate with the FWS to determine the type and extent of surveys needed to evaluate existing conditions and potential future impacts of the flood control alternative plans. The Corps would select the party (FWS, Corps, or contractor) to conduct any biological surveys. Selection would be based, in part, on required expertise, available funds, and ability to meet the project schedule.

(5) Fund the Service for a HEP study and a Fish and Wildlife Coordination Act Report, as part of the feasibility study process.

Corps Response: Concur.

(6) Complete all aspects of Section 7 requirements of the Endangered Species Act, as amended.

Corps Response: All aspects of Section 7 requirements of the Endangered Species Act would be completed prior to initiating project construction.

(7) Obtain, prior to the Service beginning a HEP study, detailed aerial photos, preferably color infrared, taken in the spring during the period of maximum vegetation "leaf-out." Photos should be taken at or enlarged to a scale of >1:2,000.

Corps Response: We acknowledge the desirability of obtaining recent high quality aerial photographs for use in delineating vegetative cover types, as well as other environmental parameters. If this study proceeds into feasibility, we will coordinate with the FWS regarding specific imagery needs, funds available to meet those needs, and project schedule.

(8) Obtain, from the FWS, an updated Species List for the proposed project area, because the existing one is more than 90 days old.

Corps Response: An updated species list would be requested should the project proceed into the feasibility phase.

(9) Determine presence of threatened and endangered species in the project area. This includes valley elderberry longhorn beetle, Swainson's hawk, and palmate-bracted bird's-beak; other species may be added if further information indicates they may occur in the study area, or should they gain protection subsequent to the date of this report.

Corps Response: A preliminary analysis of the presence in the project area of Federally listed and other species of special concern is provided in this EE. Should the project proceed into the feasibility phase, more detailed work, including appropriate field surveys by qualified biologists, would be conducted to evaluate the presence of protected species in the project area.

(10) Consider and identify the indirect effects of the project on development in the flood plain, particularly conversion of agricultural habitat to commercial or residential uses.

Corps Response: During feasibility phase a detailed land use analysis would be completed. This analysis would include an evaluation of potential project impacts to flood plain land use.

(11) Investigate the opportunities for enhancement of the wildlife values along Cache Creek, including but not limited to: (a) restoration of anadromous fisheries to Cache Creek, (b) management of exotic species in the stream channel, and (c) use of passive systems such as low check-dams to manage vegetation where necessary, such as where the channel narrows at bridges.

Corps Response: The Corps and its potential local sponsor are very interested in restoration opportunities along Cache Creek. This reconnaissance study has included a preliminary evaluation of opportunities for restoration of anadromous fisheries and wetlands. Further development of restoration opportunities would be possible if the project enters the feasibility phase.

(12) Provide maps which clearly identify the geographical limits of flooding under different flows. The maps provided to date show the limit of flooding for only 500-year events. Information on extent of flooding under more frequent flooding events would be valuable in assessing losses of flood plain areas due to this project.

Corps Response: The Corps has developed a map showing the flood plain for the 100-, 200-, and 500-year flood events. The flood plain actually remains the same for all events; however, the depth of flooding varies. Flood plain maps would be provided to the FWS during the feasibility phase.

(13) Consult the California Natural Diversity Database to obtain data on presence of resources of special concern in the study area; 90 occurrences are known from the three topographic 7.5 minute quads which include the study area.

Corps Response: The Corps completed a NDDB search for the area affected by the flood control and environmental restoration alternative plans. The results of the search are provided in the sections titled, Rare, Threatened, and Endangered Species, and in Table 4 of this EE.

(14) Explore "nonstructural" alternatives, in which areas or structures with high value would be individually protected, while other areas, such as agricultural lands, would be allowed to flood, as has occurred historically, and which in the past has been compatible with agricultural land uses.

Corps Response: Nonstructural measures were included in the Corps' preliminary evaluations. It was recognized that some of these methods would be relatively environmentally benign and should, therefore, be given serious consideration as a means to reduce potential flood damage. However, preliminary analysis identified no technically or economically feasible options.

Corp's Strategic Mitigation Plan

During this planning phase, the Corps mitigation goals for unavoidable biological resource losses are consistent with those identified by the FWS, and presented in the previous sections.

During feasibility phase a habitat evaluation procedure (HEP) would be used to determine actual habitat value lost as a result of project construction and operation, and the HEP coupled with a cost effectiveness and incremental analysis would be used to determine mitigation requirements.

For this reconnaissance-level evaluation, mitigation costs are assumed to be 10 percent of project costs. For Alternative 2, the mitigation cost for 100-year level of protection is $2.4 million and the cost for 200-year level of protection is $300 million. For Alternative 3, the mitigation cost for 100-year level of protection is $6.0 million and the cost for 200-year level of protection is $6.2 million.

Project lands along Cache Creek would be the highest priority candidate mitigation lands. Opportunities to restore riparian corridors affected by project construction, and opportunities to reestablish riparian vegetation where existing corridors are disjunct, whether on project or other lands, would strongly influence mitigation planning. Restoring or establishing high value wetland habitat on project lands or other lands within or adjacent to Cache Creek would be another potential mitigation strategy.

At this early phase of planning, it is premature to specify what mitigation, if any, would be required for impacts to cultural resources. Because cultural resources are nonrenewable, avoidance and preservation are always preferable to mitigation. If it is determined that an effect will be made by the project on historic properties, a determination must be made whether that effect will be adverse. Section 800.9(b) outlines the criteria of adverse effect, which include destruction or alteration, intrusive elements, and neglect. If a determination of adverse effect is made, mitigation measures will be formulated in consultation with the State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation. A Memorandum of Agreement could result under procedures outlined in 36 CFR 800. Mitigation measures could include data recovery through scientific excavation, archival research, recordation, relocation, and purchase of areas with comparable cultural resources.

ADDITIONAL STUDIES NEEDED

Fish and Wildlife

Additional fish and wildlife studies would probably be recommended by the FWS should one of the flood control

alternative plans proceed into feasibility phase. These studies would include:

1. Habitat evaluation procedure (HEP).

2. Draft and final Coordination Act Report (CAR).

3. Biological surveys. To fully evaluate alternative plans, some biological surveys may be needed.

Rare, Threatened, and Endangered Species

1. If this study enters the feasibility stage, an updated list of endangered and threatened species would need to be requested from the FWS. A list of State-protected species would also be obtained from the California Department of Fish and Game.

2. Surveys, conducted by qualified biologists, might be needed to determine the presence and status of some species.

3. A biological data report and biological assessment would need to be prepared.

Cultural Resources

If the study proceeds into the feasibility phase, additional cultural resources studies would be required. The scope of these would be developed in consultation with the SHPO and could include, but not be limited to, the following:

1. Further archival research using historic maps, Government Land Office records, ethnographies, and other documents to more accurately ascertain the likelihood of locating additional archeological, historical, and ethnographic sites.

2. Information on sites of ceremonial or religious concern to Native Americans.

3. Public involvement including Native Americans, historical societies, and other interested persons or groups.

4. Examination of all areas not previously surveyed and areas surveyed prior to 1980 for cultural resources. Revisitation of previously recorded sites.

5. National Register evaluation of cultural resources within the Area of Potential Effect.

6. Determination of effect in consultation with the SHPO.

Hazardous, Toxic, and Radiological Waste

Any HTRW sites located in the study area could require special design or construction considerations for the restoration work. An updated literature survey and field reconnaissance of the study area would be conducted during advanced studies to determine if there are any unlisted HTRW sites in the project area.

The Corps has developed agency policy in response to CERCLA, which holds certain categories of individuals strictly liable for all clean up and response costs of any hazardous substances regulated under CERCLA. This policy states that between the Government and the local sponsor, it will generally be the local sponsor's responsibility to assure clean up and pay all response costs of any HTRW sites located on a Civil Works project. However, if HTRW material exists within the construction area, the Government will determine as soon as possible the extent and nature of the contaminated material prior to construction. If already in construction, the Government and local sponsor shall decide whether to continue construction, terminate construction, or, if possible, redesign the project. In any event, should the Government and local sponsor decide to proceed or continue with construction after considering any liability that may arise under CERCLA, the local sponsor will be responsible for any studies, investigations, clean up and response costs. In addition, the local sponsor shall operate, maintain, repair, replace, and rehabilitate the project in a manner so that liability will not arise under CERCLA.

Land Use

1. A land use analysis would be needed. Emphasis should be placed on potential impacts to the flood plain.

Restoration Benefits

1. An appropriate quantitative and qualitative analysis of benefits would be required. Some information for this analysis would come from the FWS' HEP.

Cost Effectiveness and Incremental Analysis

1. These analyses are required for both restoration and mitigation planning.

COORDINATION

A "Notice of Initiation of a Reconnaissance Study, Westside Tributaries to Yolo Bypass, Flood Control Investigation, California," was sent to Federal, State, county, and city agencies, and other interested parties in May 1993. The purpose of the notice was to identify information on flood control problems and significant natural resources in the areas. Comments received were considered in the development and evaluation of flood control and environmental plans for the study area. Letters of comment are provided in Appendix E.

On September 21, 1993, the Corps briefed the Yolo County Board of Supervisors on the purposes of the study and the preliminary results to date. The members of the Board asked questions, made comments, and asked that the Corps participate in the Yolo-Solano County Flood Control Task Force. The meeting was also open to other public agencies, organizations, and interested individuals in the study areas. Comments focused on flooding along Cache Creek and Willow and Dry Sloughs, land subsidence, gravel mining, and affects of the project on the settling basin.

The Corps attended several subsequent meetings of the Yolo-Solano Flood Control Task Force. At the December 8, 1993, meeting, the Corps presented preliminary results of the westside tributaries study.

During feasibility studies, a public involvement program would include information summaries, meetings with special interest groups, and a formal public meeting to be held near the conclusion of the study.

Development of this EE has been coordinated with in-house staff of the Environmental Resources Branch, the study manager, Borcalli and Associates, Inc. (Corps' contractor),and relevant Corps technical staff. Coordination with the FWS, National Marine Fisheries Service, and local recreation and environmental interests has also been important to the development of this report.

FINDINGS AND CONCLUSIONS

Information reviewed and evaluated during preparation of this EE indicates that both flood control alternative plans could have significant environmental impacts. Terrestrial and aquatic habitat as well as cultural resources could be adversely affected by project construction. Of the two flood control alternative plans, Alternative 2 (setback levees) would be the least environmentally damaging. If this becomes a feasibility level

study, it should be anticipated that adjacent landowners, development speculators, FWS, and environmental groups will be very interested in potential flood plain impacts. An EIS would be required during the feasibility phase.

Conclusions regarding potential adverse environmental impacts from the restoration alternative plans are less certain. Clearly, opportunity exists to restore degraded ecological resources along Cache Creek. Fish, wildlife, and plants could significantly benefit from this restoration work. However, sufficient information was not identified during preparation of this EE to determine whether or not significant adverse impacts would occur from implementation of either of the environmental restoration plans. Planning for restoration of historic fisheries in Cache Creek would require particular care and close coordination with resource agencies would be essential. Planning for gravel pit wetland restoration should include attention to potential public health concerns and coordination with the Sacramento County-Yolo County Mosquito Abatement District. During feasibility, a more in-depth EA could be prepared to more clearly determine the need for an EIS, or an EIS could be initiated without first completing an EA.

Finally, it should be noted that opportunity exists for multi-objective (flood control, environmental, recreation) planning along Cache Creek. A more comprehensive system of setback levees, located on both sides of Cache Creek, could meet medium and long-range flood control, environmental, and recreation needs. Short term financial costs may exceed those of more conventional approaches. Support for setback levees designed to maintain and/or restore the integrity of riverine ecosystems is increasing both regionally and nationally. Resource agencies, professional and research ecologists, and elements of the public, are beginning to advocate this approach. It should be anticipated that this base of support will continue to expand. Therefore, during feasibility phase, full consideration of a multi-objective setback levee plan is strongly recommended. Information developed and displayed in planning and environmental documents would provide decision makers and the public with essential data on the potential costs and benefits of this approach.

LIST OF PREPARERS AND REVIEWERS

Name Discipline/ Expertise	Experience	Role in Preparation
Irene Davies Civil Engineer/ Study Manager	4 yrs planning studies, Corps	Review
Jerry Fuentes Social Scientist/ Historian	4 yrs planning studies, Corps	Cultural resources
Debbie Giglio Biologist/ Environmental Planner	2 yrs environmental studies, Corps	Research and impact analysis
Alicia Kirchner Engineering Technician	3 yrs planning studies, Corps	HTRW research
Lynne Stevenson Technical Writer/ Editor	8 yrs environmental and planning studies, Corps; 10 yrs professional librarian	Writing and editing
Tanis Toland Ecologist/ Environmental Planner	3.5 yrs environmental studies, Corps	Research, writing, and review

BIBLIOGRAPHY

Bean, Walton. 1968. California: An Interpretive History. McGraw-Hill, Inc., New York.

California Department of Conservation. 1992. Farmland Conversion Report 1986 to 1988. Office of Land Conservation, Farmland Mapping and Monitoring Program.

California Department of Conservation. September 1990. Farmland Conversion Report 1986 to 1988. Office of Land Conservation, Farmland Mapping and Monitoring Program.

California Department of Conservation. June 1990. Map. Office of Land Conservation, Farmland Mapping and Monitoring Program.

California Employment Development Department. 1992a. Annual Planning Information for Colusa, Solano, and Yolo Counties.

California Employment Development Department. 1992b. Annual Planning Information; Yolo County. Sacramento, California.

California State Department of Finance. 1992. California Statistical Abstract. Sacramento, California.

California State Department of Finance. 1990. California Statistical Abstract. Sacramento, California.

Chartkoff, Joseph L., and Kerry Kona Chartkoff. 1984. The Archeology of California. Stanford University Press, Stanford.

Far Western Anthropological Research Group (FWARG). n.d. Yolo Basin Wetlands Investigation Cultural Resources Survey. Report in progress for Sacramento District Corps of Engineers.

Government Land Office Records (GLO).

Hallock, Richard J. 1987. Sacramento River System Salmon and Steelhead Problems and Enhancement Opportunities. A Report to the California Advisory Committee of Salmon and Steelhead Trout.

Hambling, Mark. September 22, 1993. Personal communication. Yolo County Planning Department.

Hoover, Mildred Brooke, et al. 1990. Historic Spots in California. 4th ed. revised by Douglas E. Kyle. Stanford University Press, Stanford.

Hornor, Edith R., ed. 1993. California: Cities, Towns & Counties: Basic Data Profiles for All Municipalities and Counties. Information Publications, Palo Alto.

Johnson, Patti J. 1978. "Patwin" in Robert F. Heizer (ed.), Handbook of North American Indians: California (Volume 8). U.S. Government Printing Office: Washington, D.C.

Jones and Stokes Associates, Inc. 1994. Suitability Analysis for Enhancing Wildlife Habitat in the Yolo Basin. January 18, 1994. (JSA 90-285.) Sacramento, CA. Prepared for Central Valley Habitat Joint Venture. Sacramento, CA.

Jones and Stokes Associates, Inc. 1990. Inventory of the wetland and riparian habitats of Yolo County, California. Final report. (JSA 89-275.) Sacramento, CA. Prepared for Yolo County Community Development Agency, Woodland, CA.

Kelley, Robert. 1989. Battling the Inland Sea. University of California Press, Berkeley.

Larry Walker Associates. April 1988. City of Davis Water Pollution Control Plant: Technical Report Regarding Effluent Suspended Solids Violations. Davis, CA. Prepared for the City of Davis, CA.

McGowan, Joseph A. 1961. History of the Sacramento Valley, 3 vols. Lewis Historical Publishing, New York.

Moratto, M.J. 1984. California Archeology. Academic Press, Orlando.

Moyle, Peter B. 1976. Inland Fishes of California. University of California Press: Berkeley.

National Marine Fisheries Service. April 24, 1991. Letter to the Corps.

Reiger, J.P and D.A. Kreager. 1989. Giant Reed (*Arundo donax*): A climax community of the riparian zone, IN, Proceedings of the California Riparian Systems Conference. U.S.D.A. Forest Service Tech. Rep. PSW-110, Pacific Southwest Forest and Range Experiment Station, Berkeley, California. Pp. 222-225.

Stallman, Jay D. December 10, 1992. Yolo Regional Open Space. Undergraduate thesis in landscape architecture, University of California at Davis.

U.S. Army Corps of Engineers (Corps). 1993. Hydrology of the Westside Tributaries of the Yolo Bypass, California. Office Report. Hydrology Section, Sacramento District.

U.S. Army Corps of Engineers (Corps). 1975. Information Brochure. Investigation for Flood Control and Related Purposes, Cache Creek Basin, California. Sacramento District.

U.S. Fish and Wildlife Service (FWS). March 23, 1994. Draft Planning Aid Report for Westside Tributaries to Yolo Bypass Reconnaissance Study, California. Sacramento Field Office.

U.S. Fish and Wildlife Service (FWS). 1992a. Planning Aid Report for Cache Creek/Clear Lake Flood Control Project, Lake County, California. In Appendix 2 of Appendix A to the Cache Creek Basin (Lake County), California Reconnaissance Report, October 1992, Sacramento District, U.S. Army Corps of Engineers.

U.S. Fish and Wildlife Service (FWS). 1992b. Yolo Basin Wetlands Project; A Detailed Report on Fish and Wildlife Resources. Sacramento Field Office, U.S. Fish and Wildlife Service. In Attachment 5 of Appendix D to Yolo Basin Wetlands Sacramento River, California, April 1992, Sacramento District, U.S. Army Corps of Engineers.

U.S. Fish and Wildlife Service (FWS). May 28, 1991. Planning Aid Letter for the Northern California Streams Flood Control, Yolo Bypass, California Project. Sacramento Field Office.

U.S. Fish and Wildlife Service (FWS). 1991a. Federal Register, Vol. 56, No. 249. Proposed Endangered Status for the Giant Garter Snake. FWS Field Office, Sacramento, CA.

U.S. Fish and Wildlife Service (FWS). 1991b. The Distribution, Habitat, and Status of the Valley Elderberry Longhorn Beetle. FWE Field Office, Sacramento, CA.

U.S. Fish and Wildlife Service (FWS). 1991c. Fish and Wildlife Resource Management Options for lower Putah Creek. Report to Congress. Sacramento, CA.

U.S. Fish and Wildlife Service (FWS). 1991d. Yolo Basin Wetlands Creation and Restoration Project. A detailed

report on fish and wildlife resources. Sacramento Field Office.

Wilson, N.L. and A.H. Towne. 1978. Nisenan. IN Handbook of North American Indians, Volume 8, California. ed. Robert Heizer. Smithsonian Institution, Washington, D.C.

Yolo County. July 17, 1983. Yolo County General Plan. Part 1: The Plan and Referenced Environmental Impact Report.

APPENDIX A

PLANNING AID REPORT FROM FWS

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacrament, California 95825-1846

March 23, 1994

Mr. Walter Yep
Chief, Division of Planning
Corps of Engineers, Sacramento District
1325 J Street
Sacramento, California 95814-2922

Subject: CESAC-Westside Tributaries to Yolo Bypass Reconnaissance Study.

Dear Mr. Yep:

Enclosed are four copies of the Fish and Wildlife Service's (Service) draft planning aid report of the effects on fish and wildlife resources of flood control measures being considered in the Corps of Engineers' (Corps) Westside Tributaries Reconnaissance Study. This report does not, however, constitute the Service's detailed report as detailed in Section 2(b) of the Fish and Wildlife Coordination Act (FWCA; 16 U.S.C. 661 et seq.).

Our analysis is based on (1) project information provided by the Corps prior to March 1, 1994, (2) a literature review, (3) personal communications with experts, and (4) best professional judgement.

Due to the extremely short time frame the Corps has allowed us for preparation of this draft report, it has not yet been formally coordinated with the California Department of Fish and Game or other involved agencies. However, by copy of this letter, we are now soliciting these agencies' comments, and request that they be provided to us by April 29, 1994. All such comments will be given full consideration in the preparation of the Service's final report, or letter supplement, provided to the Corps.

If you have any questions, or need additional copies of the report, contact Dr. Gary Falxa of my staff at 978-5606.

Sincerely,

James D. Carson

for Dale A. Pierce
Acting Field Supervisor

cc: FWS, ARD, ES, Portland, OR
NMFS, Santa Rosa, CA
CDFG, Director, Sacramento, CA (Attn: Env. Serv.)
CDFG, Reg. II, Rancho Cordoba, CA (Attn: Env. Serv.)
Yolo Co. Flood Control and Water Cons. Dist., Woodland, CA (Attn: James F. Eagan)

UNITED STATES DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE

PLANNING AID REPORT

WESTSIDE TRIBUTARIES TO THE YOLO BYPASS INVESTIGATION, CALIFORNIA

Prepared by

U.S. Fish and Wildlife Service
Ecological Services
2800 Cottage Way, Room E-1803
Sacramento, California 95825

Prepared for
U.S. Army Corps of Engineers
Sacramento District

March 1994

Draft--Subject to change

TABLE OF CONTENTS

INTRODUCTION 3

DESCRIPTION OF PROJECT, WITH BACKGROUND 3

METHODS 6

BIOLOGICAL AND PHYSICAL SETTING 7
Physical Setting 7
Existing Habitat Types 8
Special Status Species 13
Mercury Contamination in the Cache Creek Drainage 16

APPRAISAL OF PROPOSED ALTERNATIVES 17
Future Conditions Without the Project 17
Future Conditions With the Project 18
General Impact Analysis 18
Specific Impacts of Alternatives 20

DISCUSSION 22
Comparison of Alternatives 22
General Mitigation Plan Features 23
Mitigation Priorities 24
Priority Habitats 24
Mitigation Locations 25
Mitigation and Enhancement Opportunities 26

Cost Estimates for Future Studies and Mitigation 27

RECOMMENDATIONS 28

LITERATURE CITED 30

APPENDIX A: Federally Listed and Proposed Endangered and Threatened Species and Candidate Species That May Occur in the Project Area . . 32

APPENDIX B: Federal Agencies' Responsibilities under Sections 7(a) and (c) of the Endangered Species Act 34

APPENDIX C: Letter to California Fish and Game Department, requesting information on state-listed species in the study area. 35

INTRODUCTION

In April 1993, the Yolo County Board of Supervisors requested the Corps of Engineers ("Corps") to determine the potential for federal participation in increasing flood protection along the west-side tributaries to the Yolo Bypass, from Cache Creek in the north to South Fork Putah Creek in the south. However, the study evaluated herein focuses almost exclusively on alternatives proposed by the Corps for flood damage control along Cache Creek, as the Corps currently anticipates no flood control work for other west-side tributaries to the Yolo Bypass (Scope of Work, 10 February 1994).

The purpose of this report is to evaluate the general impacts that future flood protection measures may have upon fish and wildlife resources along Cache Creek. This constitutes the U.S. Fish and Wildlife Service's ("Service") planning aid report (PAR), but not the detailed report as called for in Section 2(b) of the Fish and Wildlife Coordination Act (Public Law 85-624; 16 U.S.C. 661-667e) regarding the Corps of Engineers' Westside Tributaries to Yolo Bypass Flood Control Investigation. The information herein has been informally coordinated with the California Department of Fish and Game (CDFG), which will be asked to formally comment on a draft of this planning aid report.

Our report is based on project information provided by the Corps through February 1994. The report describes general impacts of flood control measures currently being investigated by the Corps on fish and wildlife resources, and discusses general alternative strategies for mitigation. As requested by the Corps, this report focuses on the Corps' anticipated recommended plan. The information presented herein is preliminary in nature, due primarily to gaps in the information currently available from the Corps. If significant changes later develop in the project's features and alternatives, our analyses herein may become obsolete and invalid.

DESCRIPTION OF PROJECT, WITH BACKGROUND

The proposed project focuses on flooding problems along Cache Creek. The creek originates at Clear Lake in the mountains west of the Sacramento Valley, and is fed by Clear Lake and tributaries downstream of the lake, with a total drainage of about 1,150 square miles. The creek's natural resources have been invaluable to the area's residents, from Patwin and other native American groups to the present agriculture-based economy. The creek has deposited rich alluvial soils broadly along its course, which today are irrigated farmland using water diverted from Cache Creek or pumped from groundwater. Agricultural development in the region has strongly impacted natural habitats, particularly the grasslands, wetlands, oak woodlands and riparian forests which once dominated the banks and floodplain of Cache Creek (Thompson 1961).

When the first European explorers and settlers came to the area, extensive areas in the Sacramento and San Joaquin Valleys flooded during years with wet winters. Numerous projects were undertaken to lessen flooding, in order to settle and farm the region's deep, rich soils. Levees were constructed along

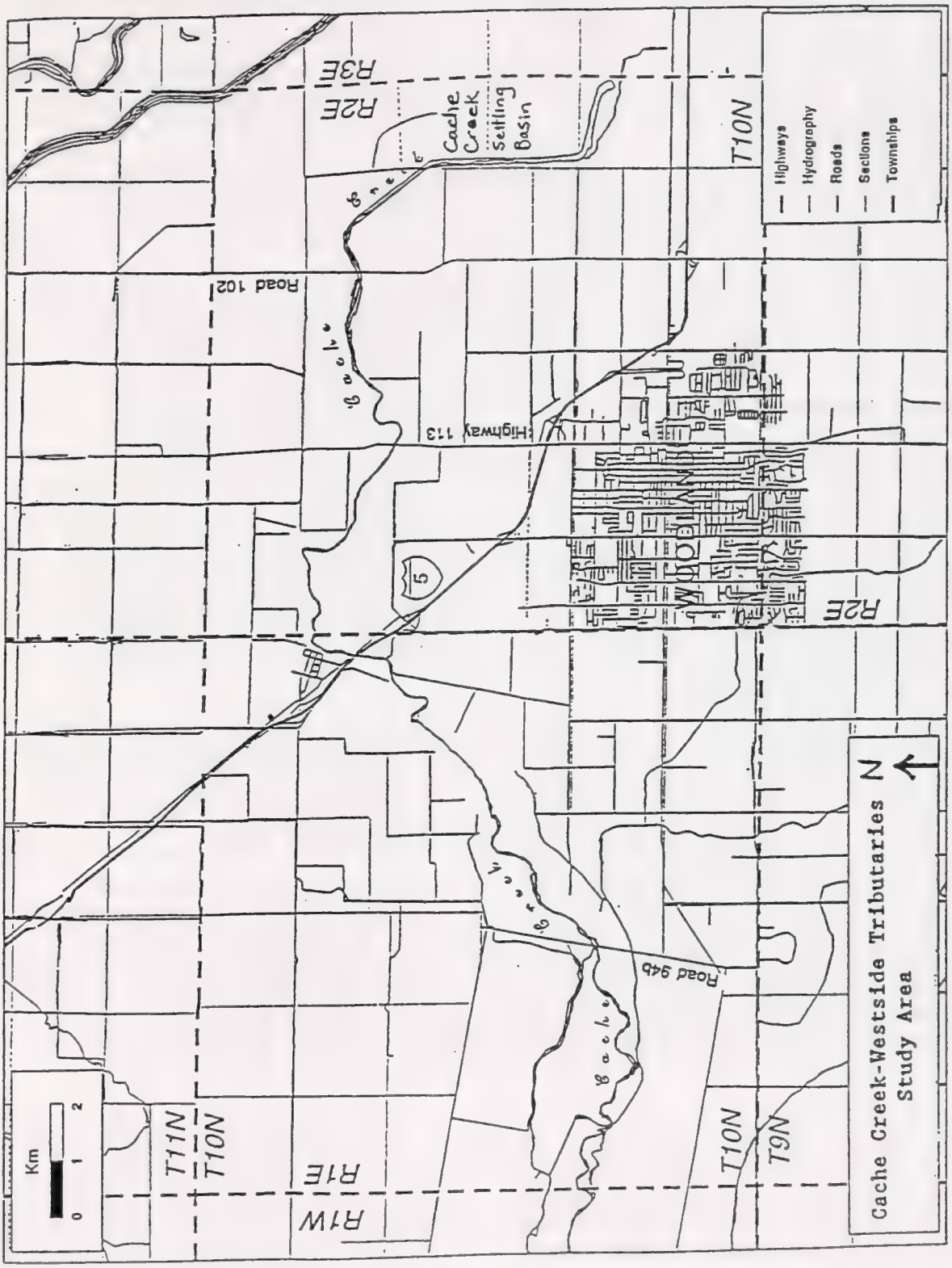
Cache Creek to lessen flood risk; these levees were enlarged in about 1961, to protect against flows of 30,000 cfs, a level which occurs at a frequency of approximately once every 10 years (Dept. of Army 1979; Borcalli and Associates 1994). Other significant structures on Cache Creek include Indian Valley Dam (built 1975; Yolo County Flood Control and Water Conservation District); Clear Lake Dam (built 1915); and a irrigation diversion dam at Capay (Yolo County FCWCD). Historically, the total flow of Cache Creek has been diverted at Capay Dam during the irrigation season (USFWS 1978).

In recent years, the Yolo County Flood Control and Water Conservation District has been increasingly concerned about flooding from Cache Creek, particularly in the lower reach, from about County Road 94b downstream to the Cache Creek Settling Basin (Figure 1). This concern was a result of various factors: the lack of an overall flood control plan for Yolo County; the lack of protection from large floods, e.g. 100-year floods; and development in the flood plain which has put structures at risk in areas formerly devoted to agriculture, which generally typically suffered little damage when flooded. High water levels in 1983 and 1986 reminded residents and officials of the lack of protection from infrequent but high water levels in the region's drainages.

The Corps has proposed 6 alternatives to lessen flood damage (Scope of Work, 10 February 1994):

1. Alternative 1: No Action. Existing conditions would continue.
2. Alternative 2: Nonstructural. This has been proposed only for Willow Slough and Putah Creek. Nonstructural methods which might be used include temporary closures for structures; ring levees; floodwalls; and structural relocations.
3. Alternative 3: Upstream Detention Basin. A floodwater detention basin would be constructed in upper Cache Creek, at Bear Creek.
4. Alternative 4: Channel Improvements. Cache Creek would be channelized from about County Road 94B downstream to the Cache Creek Settling Basin, a total of about 11.6 river miles. The channel would be enlarged in depth and width, riparian vegetation and obstructions would be removed, and the new channel slopes would be stabilized with rip-rap.
5. Alternative 5: Levee Modification/New Levees. Levees would be raised and/or newly constructed to provide protection from projected 100-year floods. The information provided by the Corps is conflicting as to the precise location of levee work, but the general area would be between County Road 94B and the settling basin.
6. Alternative 6: Set-back Levees (combined with other measures). This is the plan the Corps anticipates will be their recommendation. This plan incorporates a combination of set-back levees (i.e., new levees set back from the stream channel), rip-rap bank stabilization, and raising of existing levees. In general, this plan calls for set-back levees along one bank of the creek, and rip-rap or levee-raising on the other. The project area for this alternative would similar to that for Alternative 4.

Figure 1. Westside Tributaries project study area and surroundings.



METHODS

Estimates and analyses provided in this report represent the best professional judgements using the available information.

We estimated the effects of the different alternatives on fish and wildlife habitats using aerial photos combined with field visits to the project area. The photographs provided by the Corps, photocopies of 1:6,000 aerial photos, were found inadequate to accurately measure habitat types and cover. Field visits helped to verify habitat determinations based on the photographs, but time/budgetary restrictions and limited access to private lands prevented detailed habitat mapping and analyses.

Our analyses focus on wetland (primarily riparian) habitats, as they are the most extensive in the study area, and have the highest resource value of habitats in the project area. For most analyses contained in this report, riparian forest and scrub-shrub were lumped, as they were difficult to distinguish with available information. The extent of riparian habitats affected by the proposed alternatives was estimated by first measuring, for each bank, the length of stream channel affected by each alternative. Riparian vegetation is very linear in the study area, typically in a band averaging about 50-feet-wide along each bank; this width was based on sample measurements made in the field. Acreage of riparian habitats affected by project alternatives were estimated by multiplying the linear bank-feet of riparian habitat affected times 50 feet; the resulting number was converted to acres. For certain analyses, the entire width of the riparian corridor was used to quantify impact area. This distance was defined as the average distance between levees, and estimated to be 400 feet, based on sample measurements on aerial photos.

The average footprint width of new, set-back levees was estimated to be 100 feet. This is calculated using the mean height of 500-year levees, and levee slope specifications as stated on the engineers' drawings and report provided by the Corps. This width includes the actual levee width plus a 10-foot-wide strip on either side of the levee (Borcalli and Associates 1994).

The California Department of Fish and Game has been requested to provide information regarding state-listed threatened, endangered and special concern species in the project species. This information, when provided, will be incorporated into the final PAR or supplement, as appropriate. Other parties contacted regarding the project include James Estep, an authority on Swainson's hawks (*Buteo swainsoni*) in Yolo County, and the Yolo County Flood Control and Water Conservation District (J. Eagan, General Manager).

BIOLOGICAL AND PHYSICAL SETTING

There is surprisingly little information available on the habitat and wildlife resources in the portion of Cache Creek affected by the project. The discussion below is by necessity based on studies in similar areas in the region, and on brief field visits. Further study to document the area's biological resources would be essential prior to proceeding with any of the activities considered by the Corps.

Physical Setting

The project area includes Cache Creek and adjacent lands, within which at least six broad habitat types are found. Patterns of habitat distribution are similar along most of the creek's length in the study area, with habitats changing fairly predictably as one moves perpendicularly away from the stream channel, due to changing soil and hydrological conditions, as well as prevailing land-use patterns. Immediately adjacent to the stream channel scrub-shrub riparian vegetation occurs, in varying density and composition. Slopes between the stream channel and levee contain a mixture of riparian shrub-scrub and riparian forest, with forest often occurring above riparian scrub-shrub, especially where the channel has steep slopes. For most of the stream length a fairly level terrace occurs between the steep-sided stream channel and levees. These terraces typically are covered with dense annual grasses, with varying amounts of woody shrubs and trees; where trees occur in this zone, they are often native valley oaks (*Quercus lobata*), but also include planted non-natives such as English walnut or eucalyptus. Levees have been built on both banks of the channel in most areas, typically at distances of about 150-200 feet from the stream channel center. Levee slopes have in most areas been cleared of woody vegetation, leaving mostly annual grasses and forbs, with occasional isolated trees. Outside the levees, agricultural land uses prevail, with scattered mature oaks which are remnants of native oak woodland; also scattered among agricultural fields and orchards are narrow strips of grassland and scrub, typically adjacent to roads, fence lines, and irrigation ditches.

Stream channels in the project area may be single or multiple, and are typically bare gravel, sand and/or fine sediments, with minimal vegetation. The channel contains, in most of the project area, a seasonal surface flow which is present mostly during the late fall through spring rainy season. Flows are highly dependent upon rainfall in the drainage, as well as upon releases from upstream dams; local residents report that the stream ran above surface for most of the 1993 dry season, an event they considered notable and due to dam releases. Winter flows are often less than 100-200 cubic feet per second during periods without precipitation (Table 1), and about 379,000 acre-feet of annual discharge (USGS 1992).

Complete data on flows through the study area are not available, but some reaches contain perennial flows, including the area just above and below the Road 94B crossing. Two factors maintain surface flows in this reach: (1) a hard clay layer (Tehama formation), which forces subsurface flow to the surface, and (2) input from an agricultural drainage channel from the north, upstream of Road 94B (James Eagan, Yolo County FCWCD, pers. comm.).

Table 1. Mean monthly flows in Cache Creek, in cubic feet per second, at Yolo gauging station (data provided by US Geological Survey, Sacramento)

YEARS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1904-1914	27	55	293	2036	2425	2522	1480	723	342	151	55	16
1915-1924	5	38	257	941	1640	782	414	164	57	22	5	3
1925-1934	2	42	221	256	1094	469	549	113	13	1	0	1
1935-1944	0	20	551	1349	3080	2065	1469	213	4	0	0	0
1945-1954	0	31	486	1249	967	721	300	21	0	0	0	0
1955-1964	38	8	377	819	2261	1256	1094	82	1	0	0	0
1965-1974	0	128	810	3046	2323	1594	838	44	3	2	2	2
1975-1984	12	215	899	1434	1786	2237	1285	201	24	15	11	10
1985-1993	9	24	66	469	1155	979	100	21	15	8	7	11
1905-1993	10	62	440	1289	1859	1403	837	176	51	22	9	5
Minimum	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	6410	5020	21300	25800	29300	24700	16900	5360	1110	530	310	115

Existing Habitat Types

Riparian Forest and Riparian Scrub-shrub

Riparian forest and scrub-shrub occur along Cache Creek as a relatively narrow (35 to 75-feet-wide) band of broad-leaved deciduous trees and shrubs, on terraces and slopes above the lower stream channel. These two habitat types are lumped together here because riparian habitat in the study area often contains elements of each type (e.g., a clump of cottonwoods in an area of shrub-scrub), and because of the limited available information about existing conditions. These riparian habitats occur along both banks of Cache Creek throughout most of the proposed project area, a distance of about 10 miles.

Native trees characteristic of the Cache Creek riparian forest include cottonwood (*Populus fremontii*), arborescent willows (*Salix* spp.), and valley oak; understory plants include wild grapes (*Vitis californica*), blackberries (*Rubus* sp.), poison oak (*Toxicodendron diversiloba*), willows, and elderberry (*Sambucus mexicana*). Non-native species include giant reed (*Arundo donax*), tamarisk (*Tamarix* sp.), and locust (*Robinia pseudo-acacia*).

Riparian forests were once extensive and widespread in the region, but little of the original forest persists, due to a host of causes including agricultural development, flood control measures (including channel modifications and vegetation removal), and decreased stream flows resulting from diversions and dams upstream. Today, riparian forest occurs mostly as a narrow, intermittent fringe along Cache Creek. Seedlings of dominant riparian species such as willows and cottonwoods depend upon perturbation to create the bare moist soils required for regeneration. Thus, extant riparian forest typically occurs on slopes intermediate between the channel and levees, in areas subject to infrequent flood scouring or other disturbances. In these habitats, disturbance events are infrequent enough, on average, to allow established seedlings to grow without further disturbance.

Riparian scrub-shrub habitat is found in frequently disturbed areas (e.g., where often flooded or subject to vegetation removal), and as a stage in riparian forest regeneration following recent disturbance. Riparian scrub-shrub habitat usually lacks tall tree cover, and consists of immature trees and shrubby riparian species, particularly young cottonwoods and valley oaks, willows, blackberries, and poison oak. Introduced species are common, including woody species (e.g., tamarisk, locust (*Robinia*)) and annuals and herbs (e.g., teasel-*Dipsacus* sp.; horehound-*Marrubium vulgare*; star thistle-*Centaurea* sp.).

Riparian forest and shrub-scrub support highly diverse fauna and flora, and are often the most valuable habitats in the region (refs??). For example, among habitats found in the nearby Sacramento-San Joaquin Delta region, riparian forest contained the greatest diversity of wildlife, including both breeding and wintering species (Madrone Associates et al. 1980). Riparian trees provide nesting habitat for many birds, notably cavity-nesting species and a rich assemblage of raptors, including the State-listed Swainson's hawk. The complex habitat of riparian forest also supports many birds which glean insects from bark, leaves and leaf tangles (e.g., bushtits--*Psaltriparus minimus*, Nuttall's woodpeckers--*Picoides nuttallii*, common flicker--*Colaptes auratus*). The mammalian fauna in the project area is also diverse, including deer (*Odocoileus hemionus*), raccoons (*Procyon lotor*), beavers (*Castor canadensis*), coyotes (*Canis latrans*), and red foxes *Vulpes vulpes*). The latter species was reported by two landowners along Cache Creek; these foxes are believed to be descended from escaped fur-farm animals (Jameson and Peeters 1988).

Some of the more common wildlife species of the project area's riparian habitats are listed in Table 2.

Table 2. Some characteristic wildlife of the riparian forest and riparian scrub-shrub habitats in the Cache Creek study area.

Birds		Mammals
California quail	Bewick's wren	opossum
great horned owl	song sparrow	striped skunk
Swainson's hawk	starlings	raccoon
Anna's hummingbird	common bushtits	black-tailed deer
red-shouldered hawk	tree swallow	Botta's pocket gopher
red-tailed hawk	scrub jay	beaver
American kestrel	brown towhee	California vole
Nuttall's woodpecker	rufous-sided towhee	black-tailed jackrabbit
		Audubon's cottontail
		coyote

Riparian forest and scrub-shrub habitats generally constitute the most valuable habitats for wildlife and fish along Cache Creek. These habitats provide critical cover, food, water, and nest sites to many wildlife species.

The structural complexity of these habitats provides many microhabitats, which promotes high biological diversity. Many species, such as hole-nesting and bark-gleaning birds, are dependent on the resources offered by riparian habitats; for some species, riparian habitat is essential for population survival.

Two avian guilds, woodpeckers and raptors, were chosen to evaluate riparian forest and scrub-shrub habitats. Raptor guild members include Swainson's hawk, red-shouldered hawk (*Buteo lineatus*), and American kestrel (*Falco sparverius*); woodpecker guild members include Nuttall's woodpecker, northern flicker, and downy woodpecker (*Picoides pubescens*). Woody riparian vegetation of the project area provides valuable foraging substrate for woodpeckers, as well as for many passerine bird species, many of which also depend on these habitats for shelter and nest sites. Large-diameter trees (i.e., over 8 inches dbh), within the project vicinity are essential nesting habitat for cavity-nesting species including woodpeckers, tree swallows, wrens, and American kestrels. Red-shouldered, Swainson's and red-tailed hawks may nest in the project area or vicinity, building stick-nests in large riparian trees, and using high branches in tall riparian trees as hunting and loafing sites. Riparian forest and scrub-shrub are of generally high value to the evaluation species, and are today very scarce habitat types in the project area and general ecoregion, although they were quite abundant prior to the 19th century. Therefore, the Service finds that any riparian forest and riparian scrub-shrub habitats that would be impacted by the project should have a mitigation goal of "no net loss of in-kind habitat value or acreage"--i.e., Resource Category 2. As defined in the Fish and Wildlife Service's Mitigation Policy, "In-kind replacement" means providing or managing substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate those lost.

Palustrine Emergent Wetland

These wetland areas develop in perennially inundated sites where water depths are generally less than 5 feet. Emergent wetlands of the project vicinity are characterized by non-woody emergent vegetation, including cattails (*Typha* sp.) and tules (*Scirpus acutus*), with rushes (*Juncus* sp.), and sedges (*Cyperus* sp.) along terrestrial margins. Conditions along Cache Creek are currently unfavorable for such wetlands, because wetland vegetation is typically intolerant of the wide fluctuations in water level and periods of aridity characteristic of Cache Creek today. There has almost certainly been a drastic loss of wetlands along Cache Creek due to a combination of factors including flow reductions, channel maintenance, gravel mining, and agricultural encroachment. The most extensive wetlands in the area occur just outside the project area, in old gravel pits just upstream of County Road 94B, and along perennial reaches of the creek, notably the stretch extending about 0.25-0.5 mile on both sides of County Road 94B. While no emergent wetlands were observed in the project area during recent brief field visits, there may be some occurrences, especially in the upstream reaches of the study area.

Wildlife species which are dependent upon emergent wetlands in the project area and vicinity include many wading birds, including great blue heron (*Ardea herodias*), great and snowy egrets (*Casmerodius albus* and *Egretta thula*),

black-crowned night-heron (*Nycticorax nycticorax*), and American bittern (*Botaurus lentiginosus*). Many other birds in the project vicinity require emergent wetlands for nesting or foraging habitat; these include various ducks and passerines. Emergent wetlands do not have a rich mammalian fauna, but muskrats (introduced--*Ondatra zibethicus*) and beavers are common residents. Emergent wetland habitat is very scarce in the reach of Cache Creek under study (and in the surrounding ecoregion), and may support few of the reptiles and amphibians commonly found in wetlands (e.g. western pond turtles--*Clemmys marmorata*, garter snakes--*Thamnophis* sp.), but Pacific treefrogs (*Hyla regilla*) and bullfrogs (*Rana catesbeiana*) are to be expected.

Two marsh-nesting passerine birds--the marsh wren and red-winged blackbirds--and great blue herons were chosen to evaluate Palustrine Emergent Wetland. The marsh wren (*Cistothorus palustris*) and red-winged blackbirds (*Agelaius phoenicus*) are passerine species which nest and feed in emergent wetlands, and could therefore be present in any occurrences of this cover type which may be found in the project area. Great Blue herons forage extensively in wetlands on aquatic vertebrates; these herons are a highly visible species, which many people take great pleasure in observing. All three of the evaluation species are also migratory birds for which the Service has management responsibility under the Migratory Bird Act. Within the project vicinity, and the ecoregion (Central Valley) in general, palustrine emergent wetlands are relatively scarce, and would be of high value to these evaluation species. Thus, should palustrine emergent wetland areas occur in the project impact area, they should also have a mitigation planning goal of "no net loss of in-kind habitat value or acreage" (Resource Category 2).

Ruderal Habitat

Ruderal upland habitat areas of the project area are closely associated with levees and the margins of agricultural lands. This cover type frequently occupies much of the level ground between levees and where the steep slope of the stream channel begins; it often intergrades into riparian forest or riparian scrub-shrub over this distance, and locally ruderal vegetation extends to the stream channel bottom. Typically, ruderal vegetation occurs as a strip bordering levees with a width ranging from about 20 to 100 feet or more.

Ruderal vegetation of the project area includes grasses, weedy vegetation, and woody plants, in varying combinations. Native grasslands were once common along Cache Creek, but have been largely eliminated by agricultural development. Extant grasslands are now dominated by introduced annual species, which have displaced native perennial and annual grasses. Typical grass species include barley (*Hordeum leporinum*), brome (*Bromus diandrus*), wild oats (*Avena fatua*), and Italian ryegrass (*Lolium multiflorum*). Interspersed among grasses are weedy species such as yellow star-thistle (*Centaurea solstitialis*), milk thistle (*Silybum marianum*) and teasel (*Dipsacus* sp.). Woody species may include wild rose (*Rosa* sp.), baccharis (*Baccharis* sp.), and blackberry (*Rubus* sp.). Ruderal areas provide habitat for granivorous birds such as western meadowlarks (*Sturnella neglecta*), California quail (*Callipepla californica*), and sparrows and finches, and for voles (*Microtus californicus*) and pocket gophers (*Thomomys bottae*). These areas are important foraging habitat for breeding raptors, including black-shouldered

kites (*Elanus caeruleus*), Swainson's hawks, American kestrels (*Falco sparverius*), and barn owls (*Tyto alba*), and for wintering raptors, including ferruginous hawks (*Buteo regalis*) and rough-legged hawks (*Buteo lagopus*).

Agricultural Lands

Agricultural areas are found adjacent to Cache Creek. Three sub-types of agriculture occur: row and field crops, orchards and vineyards, and pasture lands. The values of these agricultural sub-types vary widely by location and seasonal. For example, in fall and winter flooded and fallow fields may provide significant habitat for migratory waterfowl, quail, pheasants, shorebirds, gulls, crows and songbirds. Fallow fields may also support high rodent populations of importance to birds of prey which feed on rodents. Orchards provide nest sites for certain birds, while vineyards are generally low in value to wildlife.

The evaluation species selected for both agricultural and ruderal habitat along the proposed Cache Creek project area are the raptor guild (including Swainson's hawks, red-tailed hawks, ferruginous hawks, American kestrel, white-tailed kite and great horned owl), and passerine ground-foraging birds (including western meadowlark, white-crowned sparrow (*Zonotrichia leucophrys*). While the values of these habitats vary according with season and crop, much of the agricultural and ruderal habitat adjacent to Cache Creek provides medium-to-high value foraging habitat for diverse assemblages of birds of prey and ground-foraging passerine birds. Furthermore, the value of these habitats adjacent to Cache Creek is often enhanced by their continuity with adjacent riparian habitats. The nearby riparian habitats provide nest and shelter sites, while agricultural and ruderal lands provide feeding sites. Both habitats have medium-to-high value, and are relatively abundant in the project area. Therefore, the Service finds that agricultural and ruderal lands to be affected by the project, should have a mitigation planning goal of "no net loss of habitat value while minimizing loss of in-kind habitat value" (i.e., Resource Category 3).

Oak Woodland

This habitat was once quite extensive along Cache Creek, but persists today in the project area mainly as single rows or isolated trees; distinct woodland patches are relatively rare in the project region. Typical oak woodland was historically characterized by a fairly open canopy layer with 20-70 percent cover, and a grassy ground cover or sparse, woody understory. Two small patches of extant oak woodland were found near the study area: a woodlot (roughly 22 acres) about 1,000 feet north of Cache Creek, just east of State Highway 113, and a patch (about 13 acres) about 600 feet south of the creek along County Road 99E. Neither patch would be directly impacted by the project activities. Isolated mature valley oak trees occur sparsely in the study area, with the notable exception of a row of trees along the creek's south side along an existing set-back levee. These oaks begin about 1.7 river miles upstream of the Interstate-5 bridge and extend for about 1 mile upstream. While not providing the quality habitat that extant woodland does, single oaks are valuable wildlife habitat and should be conserved. Oaks provide wildlife habitat that would otherwise be absent in agricultural areas. Most of the area's remaining Swainson's Hawks nest in mature oaks, and oaks

also provide breeding sites, shelter, and feeding opportunities for many other wildlife species (Verner 1980).

The evaluation species selected for oak woodland that could be impacted within the project area were Swainson's Hawks, the woodpecker guild (including northern flicker, Nuttall's woodpecker, acorn woodpecker, Lewis's woodpecker), and the oak insect community (Table 3). Oaks are important to Swainson's hawks as nest sites, and to woodpeckers as nest and foraging sites. Isolated oaks also provide scarce shade and shelter to many other species. Several species are closely linked to oak forest, including acorn woodpeckers and western gray squirrel (*Sciurus griseus*), and acorns are a nutrient-rich food used by many wildlife species. Oaks also support a rich and complex insect community, including leaf-miners (Opler 1974), and many species of gall-forming insects, which in turn are host to many parasitic insects. Oak insect communities have been the subject of many important studies of ecological community structure and dynamics. Because of the high value of oak woodland to the evaluation species, and because native oaks are a scarce and dwindling habitat in the Sacramento Valley, the Service finds that oak woodland affected by the project should have a mitigation planning goal of "no net loss of in-kind habitat value" (i.e., Resource Category 2).

Table 3. Evaluation Species, Resource Categories, and mitigation goals for the habitat types in the Cache Creek portion of the Yolo Bypass Westside Tributaries Project area.

Habitat Type	Evaluation Species	Resource Category	Mitigation Goals
Riparian forest and Riparian scrub-shrub	Woodpecker guild, raptor guild	2	No net loss of in-kind habitat value or acreage
Agricultural and Ruderal Habitats	raptor guild, ground-foraging birds	3	No net loss of habitat value while minimizing loss of in-kind habitat value
Oak Woodland	Woodpecker guild; Swainson's hawk; oak insect communities	2	No net loss of in-kind habitat value
Palustrine Emergent Wetland	marsh wren; red-winged blackbird; great blue heron	2	No net loss of in-kind habitat value or acreage

Special Status Species

Federally-listed Threatened and Endangered Species

Species which may occur in the project area were listed in the Service's October 26 1993 letter to the Corps. This list included federally-listed endangered and threatened, proposed, and candidate species (Appendix A).

Two federally-listed threatened species may occur in the study area: the giant garter snake (*Thamnophis gigas*) and the valley elderberry longhorn beetle (*Desmocerus californicus*). Two federally-listed endangered species may occur in the study area: palmate-bracted bird's-beak (*Cordylanthus palmatus*), an annual plant; and bald eagles (*Haliaeetus leucocephalus*). A third endangered species, the American peregrine falcon (*Falco pereginus anatum*), was not on the list provided by the Service, but may be present also.

Giant garter snakes inhabit sloughs, ponds, small lakes, low-gradient streams and other waterways, such as irrigation and drainage canals. It feeds primarily on small fishes and frogs. Some of the habitat requisites for this snake consist of adequate water during the snake's active season (early-spring through mid-fall) to provide food and cover, and emergent, herbaceous wetland vegetation such as cattails and bulrushes, for escape cover and foraging habitat during the active season. The giant garter snake inhabits small mammal burrows throughout its winter dormancy period (November to mid-March). Urban expansion, flood control projects, and other human activities currently threaten the survival of this snake throughout its range (USFWS 1991a). Should field surveys find giant garter snakes in the project area, project work in the riparian zone may negatively affect the species.

Valley elderberry longhorn beetles require elderberry bushes to complete their life cycle; larvae live in hollowed stems, and adults feed on elderberry foliage (USFWS 1991b). The beetle probably exists in the project area. Elderberries are widespread in varying densities along Cache Creek in the project area, and during field visits in February 1994, evidence (exit holes, hollowed stems) of this beetle were observed in several locations. Removal of elderberry shrubs reduces available habitat and could result in a negative impact to the beetle. This impact could either be the "take" of individual beetles, or long-term reduction of beetle populations due to habitat loss. Elderberry shrubs generally occur on higher-terrace banks of the riparian zone, and thus could be subject to adverse impacts due to any construction activity conducted above the stream bed.

Bald eagles are known to migrate through and winter sparsely in the Sacramento Valley. They feed mainly on fish, and by scavenging on waterfowl and mammals. They generally require lakes, reservoirs, or free-flowing rivers with abundant fish, and adjacent snags or other perches. A substantial number of bald eagles winter along the upper waters of Cache Creek, near Clear Lake, but eagle use in the study area would likely be brief under current flow conditions. It is not likely that the project would have a significant impact on bald eagles.

Peregrines can be expected to occur in the project area outside of their nesting season, as there is no suitable nesting habitat--high cliffs--in the area. Peregrines could occur here both as wintering birds and in transit during migration. The project area does not contain high-quality habitat for peregrines, although much of the riparian and adjacent agricultural habitat could be used occasionally as hunting and loafing habitat by individual falcons. These habitats support populations of small- to medium-sized birds,

which are peregrines' principal food. However, it is not likely that the project would have any significant impact on the peregrine falcon.

The palmate-bracted bird's-beak is a listed endangered plant that may be found in the project area. Historically, the species was collected from localities in Alameda, Fresno, Madera, San Joaquin, Yolo, and Colusa counties. Impacts could result from direct physical destruction of the plant or degradation of habitat during construction activities. This plants occurs mainly on relatively undisturbed, seasonally-flooded, saline-alkaline soils in alkali sink habitat. It is associated with halophytes such as alkali heath (*Frankenia grandiflora* ssp. *campestris*), alkali weed (*Cressa truxillensis* ssp. *vallicola*), pickleweed (*Salicornia* spp.), seepweed (*Suaeda* spp.), iodine bush (*Allenrolfea occidentalis*), and some species of saltbush (*Atriplex* spp.). Palmate-bracted bird's-beak blooms from May through October.

To the best of the Service's knowledge, no proposed (for threatened or endangered) species are known to occur in the project area. However, several Federal candidate species may be found in the project area:

Fish
Sacramento splittail (*Pogonichthys macrolepidotus*)

Amphibians
western spadefoot toad (*Scaphiopus hammondi hammondi*)
California tiger salamander (*Ambystoma californiense*)
foothill yellow-legged frog (*Rana boylei*)
Reptiles
northwestern pond turtle (*Clemmys marmorata marmorata*)

Birds
ferruginous hawk (*Buteo regalis*) (not on Sec. 7 list, but observed in area during field visit in February 1994)
tricolored blackbird (*Agelaius tricolor*)
mountain plover (*Charadrius montanus*)
loggerhead shrike (*Lanius ludovicianus*)

Mammals
Pacific western big-eared bat (*Plecotus townsendii*)
greater western mastiff bat (*Eumops perotis californicus*)
San Joaquin Valley woodrat (*Neotoma fuscipes riparia*)

Plants
recurved larkspur (*Delphinium recurvatum*)
adobe lily (*Fritillaria pluriflora*)
Brewer's dwarf-flax (*Hesperolinon breweri*)
California hibiscus (*Hibiscus californicus*)
Hind's walnut (*Juglans hindsii*)
Contra Costa goldfields (*Lasthenia conjugens*)
few-flowered navarettia (*Navarettia pauciflora*)
Gairdner's yampah (*Perideridia gairdneri ssp. gairdneri*)

The brief discussion above of federally-listed threatened and endangered species should be regarded as preliminary information, which the Service is providing to assist the Corps in consultations and/or preparation of any Biological Assessment for the project, should one be deemed necessary. The Corps' responsibilities for such assessments, and for compliance with sections 7(a) and (c) of the Endangered Species Act of 1973, as amended (Act), are briefly outlined in the attached Appendix B. In addition, the Service recommends the Corps review all of its responsibilities under the Act and the procedural regulations governing interagency cooperation under section 7 (50 CFR 402). Generally, it is the policy of the Service's Sacramento Field Office that a *final* Fish and Wildlife Coordination Act report for a proposed project will *not* be issued until compliance with the Act has been demonstrated.

California State-listed Threatened and Endangered Species
Information has been requested from the California Department of Fish and Game (Appendix C). This information will be provided in the final version of this PAR, or in a supplement, as appropriate. However, some species recognized by the state as endangered, threatened, or rare may occur in the project area. These include Swainson's hawks, bank swallows, and giant garter snake. Swainson's hawks are definitely in the project area and are known to nest (several pairs) along Cache Creek (James Estep, Jones and Stokes Inc., pers. comm.).

Swainson's hawks are locally common summer residents in parts of the Central Valley and Great Basin regions. This species nests in North America and migrates in the fall to grasslands of South America as far south as Argentina. Swainson's hawks nest primarily in riparian areas, but also nest in lone trees and groves of trees in agricultural fields, pastures, and near roads; near the project area, a number of remnant oak trees are important as nest sites. Swainson's hawks forage primarily in large open areas with suitable populations of small mammals particularly rodents. Suitable foraging areas include: native grasslands, ruderal areas, lightly grazed pastures, alfalfa and other hay crops, and certain grain crops. Agricultural crops with excessively dense or tall vegetation are generally unsuitable for foraging. The Central Valley supports an estimated 78% of the total statewide nesting population of about 550 pairs of Swainson's hawks. Yolo County contains an important concentration of nesting pairs.

Project-related impacts to these hawks could result from loss of nest trees, or from disturbance of nesting pairs, which can lead to failure of the nesting attempt. Guidelines developed by the CDFG for Swainson's hawk protection include the establishment of a buffer zone around active nest sites, usually one-half mile in radius, in which construction activities are restricted from roughly March until about September, when the young are no longer vulnerable to disturbance.

<u>Mercury Contamination in the Cache Creek Drainage</u>
Clear Lake and the Cache Creek drainage are known to contain elevated mercury levels. Sources of this mercury include leaching from natural mercury deposits, and from the Sulphur Bank Mine Superfund site on Clear Lake.

Mercury levels in Clear Lake fish collected by CDFG are high enough to cause the Department of Health Services to issue a fish consumption health advisory. Since Cache Creek drains Clear Lake, it is likely that elevated mercury levels could be found in downstream depositional areas. Fish from Cache Creek contained elevated concentrations of mercury, but not as high as in Clear Lake (T. Maurer, USFWS Contaminants Branch, pers. comm.).

Dredging, channelizing, or other work in the Cache Creek stream channel could release buried mercury from depositional areas and increase its availability to aquatic organisms and their predators. Wherever project work would include disturbances to stream deposits, sediment cores should be taken from disturbance areas, concentrating on depositional areas. These samples should be analyzed to fully assess possible mercury contamination and the potential for remobilization; this assessment should be completed prior to initiating work in stream channel.

APPRAISAL OF PROPOSED ALTERNATIVES

The brief, preliminary analyses of project impacts given here focuses on comparing Alternatives 1, 4, and 6, as requested by the Corps (I. Davies, pers. comm., 9 Feb. 1994). Based on cost analyses and the draft engineering report (Borcalli and Associates 1994), the Corps found Alternatives 3 and 5 to be infeasible. In view of these findings, and because the information provided to the Service was insufficient to fully quantify impacts, the Service has not considered Alternatives 3 and 5 further. Also, Alternative 2, as outlined in the Scope of Work, was concerned with only Putah Creek and Willow Slough, and was not addressed in the draft engineering report; it is only briefly evaluated in this document.

Future Conditions Without the Project

The general conditions detailed above under "Existing Biological Conditions" could be expected to continue in the absence of the project. Factors which may lead to some minor changes, however, include vegetation removal, spread of exotic species, and land-use changes.

The distribution and condition of riparian habitat along Cache Creek has been and will continue to be affected by human activities, including water-flow regulation and vegetation removal conducted by the Department of Water Resources, which is the State agency officially responsible for levee and channel maintenance, and by the Yolo County Flood Control and Water Conservation District, which also conducts vegetation clearing within the stream channel when vegetation is deemed a hindrance to water flow. With these current policies and practices expected to prevail in the future, riparian vegetation can be expected to continue in the present degraded state.

The value of channelization and vegetation removal has been controversial, and alternate views have emphasized values of riparian forest and shrub as natural ecosystem components, wildlife habitat, and valuable cover to help stabilize banks and control erosion. Should these views prevail and reduce future management of the riparian zone along Cache Creek, habitat values could potentially increase considerably.

Introduced species, notably tamarisk and giant reed, will probably continue to be dominant in parts of the riparian zone of Cache Creek; these two species thrive in riparian areas which are disturbed, whether by natural events (e.g., flood scouring, channel migration, and sedimentation) or by human activities (e.g., earth-moving or other construction along channels, and vegetation removal) (Rieger and Kreager 1989).

The land-use change which could most profoundly influence the biological conditions in the project area would be conversion of lands in agricultural production to residential or non-agricultural business uses, in response to increasing human populations in the region. Such conversion would have a large detrimental effect on the ability of the area to support wild plants and animals. In the absence of this proposed project, construction actually within the existing Cache Creek floodplain may be expected to be slow, however, if local agencies follow existing Federal guidelines to avoid such construction. Less marked changes in the natural communities in the project area could result should farming techniques and/or cropping patterns change, but the type and magnitude of such changes cannot be predicted.

Future Conditions With the Project

A brief, preliminary analysis has been made of both the project's general impacts, and the more specific impacts that would occur, by alternative. These initial analyses would be expanded later in the Service's more detailed reports on the project.

General Impact Analysis

Certain features common to more than one alternative have predictable impacts regardless of which alternative employs the method. The following general classes of impacts considered here are: rip-rap, raising existing levees, channelization, set-back levees, general construction activity, and effect of decreased flooding frequency in the floodplain.

Rip-rap involves lining the bank of the stream channel with stone, in order to stabilize the bank. Two long-term impacts of rip-rap are the elimination of riparian vegetation from the rip-rapped bank, and the halting of the natural wandering movement of the stream channel, with accompanying deposition and bank-cutting. The loss of riparian habitat is virtually total and unavoidable when this technique is employed. Less obvious is the loss of cut banks, which are used as nesting habitat by some birds (e.g., belted kingfishers *Megaceryle alcyon*, and bank swallows *Riparia riparia*), both of which occur in the region. Lastly, the natural process of stream channel movement produces a matrix in the riparian zone of vegetation zones of different ages, which is more complex and more diverse than what results from bank stabilization.

Raised levees require a broader base than the pre-existing levees in order to maintain preferred height:width ratios. A principal impact, thus, is that the levee will consume land. In many cases the land impacted was already ruderal habitat on levee slopes; in this case the loss of habitat would likely to be temporary, until ruderal vegetation was reestablished. In this case mitigation would not be required. Some of the footprint of raised levees

would result in a small decrease in habitat value as riparian, agricultural or unmanaged ruderal habitat is converted to levee slopes, which are often regularly cleared of vegetation. Mitigation for these losses could be achieved by replacement with wetland habitats, as part of the overall project mitigation. The amount and value of area affected would have to be determined using detailed project plans and a Habitat Evaluation Procedure (HEP).

Channelization represents a serious and unavoidable degradation of habitat, particularly because it frequently occurs in combination with other stream channel modifications, notably rip-rapping or revetment. Impacts include degradation of riparian habitat in the channel, and effects on water table due to increased drainage. Channelization often leads to increased stream velocities, which increases rates of erosion, sediment transport downstream, with further negative effects on near-stream habitats. Overwhelming evidence exists that channelization leads in general to decreases in both fish and wildlife diversity and biomass (Simpson et al. 1982).

Set-back levees are levees which are constructed some distance away from the main stream channel. Since this represents new levee, habitats are converted to low-quality levee. In the project area, the lost habitat is predominately agricultural, with smaller amounts of ruderal, riparian scrub, and oak woodland. Such losses in habitat value would require mitigation. Should the construction of set-back levees result in decreased vegetation management in the stream channel, a benefit of this construction technique might be an increase in the existence and/or value of riparian or wetland habitats between the "old" and the set-back levee.

General construction impacts include the disturbance effects of construction noise and activity on wildlife in the area. These effects generally are transient, with little lasting impacts on biological resources. When impacts on particular species can be identified, e.g. on nesting Swainson's hawks, the timing or location of impacts can often be adjusted to minimize impacts. For many species, however, the effects of disturbances are largely unknown.

Effects of decreased flooding frequency in the floodplain and resulting decreased flood risk may cause significant land-use pattern changes. For example, agricultural land may be converted to residential housing. The full impacts of decreased flooding frequency are often long-term and may be quite subtle over the short term. This is especially true with the proposed project areas that would be protected from rare--"100-year" and "500-year"--flood events. Flooded areas also provide transient habitat for wildlife such as waterfowl and wading birds. The effect of the proposed project would be a further small incremental decrease in flooding frequency, in areas that already flood relatively rarely.

While recognizing the demands for increased protection from flood damage in Woodland and other areas near Cache Creek, we are concerned with the effects of the proposed project on lands that are currently in agricultural production, and which, as such, provide valuable habitat to wildlife. As Federal agencies, the Fish and Wildlife Service and the Corps of Engineers

must heed the policy guidance set forth in Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands). The objectives of the orders are, respectively, to (1) "avoid to the extent possible the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative", and (2) "avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct and indirect support of new construction in wetlands wherever there is a practicable alternative."

Specific Impacts of Alternatives

Alternative 2: Non-structural: It is the Service's understanding that this option would focus on measures to protect individual structures in the 100/500-year floodplain of Putah Creek and Willow Slough. Assuming this to be the case, the impact of this alternative to biological resources along Cache Creek would be minimal. However, there could be significant biological impacts associated with the structure protection efforts. If this alternative resurfaces, these would need to be assessed by the Service.

Alternative 3: Upstream Detention Basin: As previously discussed, the detention basin alternative was eliminated by the Corps from consideration early in the planning process. Nevertheless, two points about this alternative's impacts are important if this alternative should later resurface: (1) it would minimize impacts to the lower stretch of Cache Creek (below Interstate 505); and (2) considerable riparian habitat in the detention basin would be subject to construction impacts and intermittent flooding. These impacts cannot be fully assessed without better information on (a) the nature and extent of construction activities, (b) the location of areas affected, (c) anticipated habitat management strategies within the detention basin, and (d) anticipated flooding regime within the detention basin.

Alternative 4: Channel Improvements: The extensive channelization and bank protection proposed under this alternative would have a severe negative impact on the biological resources along Cache Creek, due to the loss of riparian wetland habitats along the creek. A total of about 12.7 bank-miles (164 acres) of riparian habitat would be impacted. Much, if not all, of this habitat would be destroyed by channelization along the entirety of the creek, and by the 11.6 bank-miles of stone bank protection (rip-rap). In addition to numerous direct impacts, channelization and channel excavation can have many significant indirect effects on fish and wildlife, by lowering water tables and reducing periods when water is present in the channel. Since channelization would require extensive disturbance of deposits, a concern with this alternative is the potential for releasing mercury from stream sediments into the aquatic system.

Mitigation on-site for losses of these habitats would be precluded by the alterations done to Cache Creek--the proposed channelization and slope protection would be incompatible with riparian vegetation, particularly riparian forest. For reasons discussed above, mitigation off-site could not

fully replace the habitat lost along Cache Creek, and should be a last resort as a mitigation measure. If off-site mitigation should be necessary, sites within the Cache Creek drainage would be preferable to those in other drainages; and mitigation would need to be placed as close to project impact area as possible. Our brief, preliminary field survey suggests that the best potential mitigation area would be the stretch of Cache Creek between County Road 94B and Interstate 505, as discussed under mitigation strategies.

Alternative 5: Levee Modification/New Levees: This alternative was also eliminated by the Corps from consideration early in the planning process. Specific impacts of this alternative cannot be estimated without more information on location and extent of construction activities. The general classes of impacts of levee modification and new levees, which are addressed under Alternative 6, would be:

- Loss of riparian habitats on the stream side of levees, and associated losses of biological diversity and biomass;
- Temporary and long-lasting effects of construction on areas adjacent to levees;
- Long-term loss of habitats under sites of new levees; and
- Indirect effects of flood protection on land uses in the flood plain.

Alternative 6: Set-back Levees: This alternative as proposed by the Corps would affect a total of about 9.7 miles of Cache Creek. Substantial impacts would result from the approximately 11.5 bank-miles of new, set-back levees, 5.4 bank-miles of rip-rap, and 2.6 bank-miles of existing levees which would be raised.

Rip-rapping would have the greatest effect, reducing or eliminating about 8 bank-miles (50 acres) of riparian forest and scrub-shrub. Rip-rapping and associated maintenance regimes typically preclude the reestablishment of riparian vegetation, thus habitat losses in rip-rapped areas would create a considerable mitigation need.

The raising of existing levees would impact about 4.7 bank-miles (17 acres) of riparian forest and scrub-shrub. These losses could be short-term, or long-term, depending on the extent of the zone affected by construction, the nature of the disturbance, and levee maintenance schedules. Because these riparian habitats are often separated from levees by 30 feet or more, losses might be minimized to much less than 17 acres by restricting levee construction work to the lands immediately adjacent to levees.

The construction of set-back levees would directly impact about 140 acres of land under the footprint of the levees, and could indirectly impact up to 660 acres located between existing levees and the new, set-back levees. Most of this potential impact area is currently low-to-moderate value (to fish and wildlife) agriculture, including row-crops, walnut orchards, and grain crops. The land use and habitat values of some of these lands will likely change with the construction of set-back levees. The impact on these lands is hard to predict. One effect of set-back levees is that land between the set-back levees and the stream may be flooded more frequently, assuming that existing levees are not maintained in areas where set-back levees are constructed.

DISCUSSION

Comparison of Alternatives

The Service's most preferred alternative, from a fish and wildlife standpoint is no action. The no-action alternative would have the least biological impact, as would be expected, given the nature of work proposed in the other alternatives.

Among the two other alternatives presented in detail by the Corps, Alternative 4 (channelization) would clearly have the greatest harmful effect on the region's biological resources. Mitigation for this alternative would be problematic, because the impacts of channelization and rip-rap could not be effectively mitigated. A net loss of up to 11 miles of a biologically valuable riparian system could thus occur. Suitable sites for mitigating up to 11 miles of lost riparian habitat would be difficult to find, as other creeks in the region already support riparian vegetation comparable to that which will be lost. The option exists to enhance the value of existing riparian forest and scrub-shrub, but this too would be difficult without substantial and costly land acquisition and modification of current flood-control practices. Also, as discussed, location of mitigation off-site would not effectively mitigate for habitat losses on-site. For these reasons, the Service recommends strongly against Alternative 4.

The Service's preferred action alternative would be a *modified* Alternative 6. The Service recommends modification of this alternative to incorporate more set-back levees and much less rip-rap, in order to preserve and enhance biological resource values in the project area. These topics are discussed below.

Proposed Modifications to Alternative 6

Alternative 6 (the Corps' preferred alternative) would have a smaller, yet still significant effect on biological resources in the project area, compared to Alternative 4. However, the set-back levees could be designed to be a very positive feature, and could markedly lower the biological impacts of increased flood protection, compared to channelization, rip-rap, or raising of existing levees. However, considerable riparian habitat losses along Cache Creek would still occur along the side of the channel stabilized with rip-rap.

This alternative could be modified to improve its values in several ways. These include:

- Set the levee very far back. This would allow for unlimited vegetation regrowth on the stream-side of the levees.
- Construct a sinuous channel along the stream-side of the set-back levees. Such a channel should be designed to carry water during high flows, and should be managed to promote growth of riparian forest and shrub-shrub habitat along the created channel.
- Manage the habitat within the set-back levee to provide for a mosaic of habitats, including depressions and ponds which can be managed as seasonal wetlands, with water supplied (at least in part) by the added stream channel. The material removed to create these depressions could

be used to raise new and/or existing levees, and thus could have multiple benefits.

- Enhance and restore the "old" levee slopes which are left inside set-back levees to provide higher-value riparian vegetation.

The modification to this alternative which would *avoid* the most impacts would be to use set-back levees on *both* sides of the channel. This would be the Service's most preferred approach because, more than any other alternative, it would preserve and enhance the values of the riparian zone, and minimize disruption to existing habitat values, including the continuity of the riparian corridor.

Finally, a factor which would have a large impact on habitat values in the project area is the policy towards vegetation in the stream channel. The values of riparian habitat along Cache Creek would be higher for mature riparian forest compared to riparian shrub-scrub. While recognizing that vegetation management is not the responsibility of the Corps, the design of the project can influence the need for vegetation removal along levees and adjacent to the stream channel. The Service recommends that, should the project be pursued further, the Corps seek out and incorporate plan features which would require minimum vegetation control (e.g., Hynson et al. 1985) and permit maximum--i.e., unlimited--development of mature riparian forest. One option which may achieve this goal might be to use, wherever possible, levees set back sufficient distance that the contained stream channel can accommodate 100-500 year flows in the presence of mature, dense, riparian forest.

General Mitigation Plan Features

The Service's mitigation goals for the potentially affected habitats were outlined earlier (Table 3). All habitat mitigation should be based on a detailed mitigation plan. This plan should include, as a minimum, the following information:

1. Baseline information on the project's impact sites, which will provide a standard to asses whether mitigation efforts successfully replace lost habitat. Essential baseline information would include presence and abundance of wildlife species in different seasons, and baseline vegetation information, including species composition and density, shrub and tree canopy cover, and tree height.

2. Early stages of mitigation efforts should assess suitability of sites to support the mitigated habitat types with minimal management once established--i.e., habitat should be matched to sites, so habitat, once established, should persist indefinitely without frequent or intensive management. Factors to be considered include soil types, hydrology, and proximity to other areas of similar habitat. The latter factor helps ensure continued survival of plant and animal populations on site, by providing a "metapopulation"--a network of interlinked populations throughout which animals and plants (via seeds) move. Populations linked by such a habitat network are more likely to persist than those in isolated habitat patches.

3. A program to monitor the development of plant and wildlife communities on mitigation sites. Monitoring criteria should include quantitative measures which enable comparison with impacted habitats. Criteria should be adequate to determine whether mitigation areas equal or exceed the quality of the highest quality of habitat being impacted; for a given habitat type, this highest-quality habitat may be used as the reference site by which to judge mitigation success. Exact mitigation needs could be determined using the Service's Habitat Evaluation Procedure (HEP).

4. Monitoring at mitigation sites should continue until all mitigation success criteria are met; this time period should at the very least continue through more than one generation of the longest-lived species (e.g., trees), to ensure that successful reproduction and replacement is occurring. If any success criteria are not met, specific remedial-actions must be stated and then promptly implemented. Reports should be prepared after each monitoring session, which include discussion of remedial efforts taken if mitigation goals are not being met.

Mitigation Priorities

Priority Habitats

After *avoidance* of project impacts has been maximized, any other necessary mitigation strategies, including replacement mitigation as appropriate, should focus on creating, restoring, enhancing, or protecting wetlands to offset project-induced losses of habitats. Of the several habitat types that could be affected by the proposed alternatives, the wetland habitats are of the highest resource categories. This reflects their importance for a rich wildlife community, as well as the drastic reduction of wetlands which has already occurred in the Central Valley and throughout the state.

Wetland habitats potentially impacted by the work would include riparian forest, riparian shrub-scrub, and palustrine emergent wetlands. The first two habitats would likely experience the greatest losses, and would need to be replaced in kind. The Service's definition of *in-kind replacement* is "to provide or manage substitute resources to replace the habitat value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate those lost."

Ruderal, agricultural, and oak woodland habitats would also be impacted by the proposed work, primarily in the "footprints" of new and raised levees. Ruderal and agricultural habitats in the project area have been assigned to Resource Category 3, and so do not need to be fully replaced by in-kind habitat. Losses to ruderal and agricultural habitats could probably best be mitigated for by the enhancement of wetland habitat values. However, oak woodland habitat impacted by the project should be mitigated for by replacement in-kind, as defined above for Resource Category 2.

Mitigation Locations

Three primary mitigation locations focusing on mitigation for the Corps' recommended alternative are considered here. These locations are:

- within the project area along Cache Creek (recommended);
- along Cache Creek outside the project area (second choice); and
- outside of the Cache Creek drainage, e.g., along Putah Creek (not recommended; use this approach only as a last resort)

The Service recommends that mitigation along Cache Creek be given highest priority, for two reasons. First, populations of many species use both the riparian corridor and surrounding lands. The existing riparian vegetation, albeit somewhat degraded, represents essential feeding, nesting, and shelter habitat for many species which use both the riparian corridor and surrounding lands. Thus, loss of riparian habitat would negatively affect species numbers and diversity over an area much larger than the creek's narrow corridor. Riparian habitat provided at some distant locations, such as Putah Creek, would not replace the habitat used by populations along Cache Creek. The net effect would be an additional regional loss of habitat.

Second, the riparian vegetation along drainages such as Cache Creek provide an important corridor for movement of wildlife throughout the region. Continuity of the habitat, as it currently exists, is important for dispersal, migration, and other movements. Loss of sections of riparian habitat in the corridor would fragment the riparian habitat, and decrease its value as a movement corridor. Habitat fragmentation also leads to loss of species diversity within fragments, both by increasing local extinction rates and by excluding from fragments individuals of species which require large areas of habitat.

Because of the importance of riparian habitat geometry, our mitigation recommendations would likely incorporate steps to conserve the continuity of riparian habitats:

- We would seek to fully replace the linear aspect of any habitat lost along the creek.
- We would also seek to maintain riparian habitat on at least one bank of the creek throughout the project area. Thus, where the project results in loss of habitat along one bank, mitigation along the opposite bank should be considered first, either through creation or enhancement of existing riparian habitat, before using off-site locations.

Should off-site mitigation be necessary, sites within the Cache Creek drainage are preferable to those along other streams, and mitigation should be placed as close to the project impact area as possible. A preliminary search suggests that one good potential mitigation site would be the stretch of Cache Creek between County Road 94B and Interstate 505, as discussed under mitigation strategies. This area has been and continues to be the site of extensive surface gravel mining; abandoned gravel pits pre-dating reclamation laws are numerous in this area. Many are biologically depauperate, and might provide suitable sites for restoration of perennial and seasonal emergent wetlands, riparian forest and scrub-shrub, and for oak woodlands (Zentner and Zentner 1993). Another, but generally less desirable, mitigation site would be the Cache Creek Settling Basin.

For reasons discussed in the introduction to this section, we would generally recommend against using any sites along other drainages to mitigate for habitat losses along Cache Creek.

Mitigation and Enhancement Opportunities

The project area presents several opportunities to mitigate for lost habitat, and to further enhance the value of the biological resources of the Cache Creek ecoregion. The Service recommends the Corps investigate the following mitigation and enhancement opportunities:

1. Habitat Within Set-back Levees

The areas enclosed within any set-back levees present an excellent opportunity to mitigate and/or substantially enhance the quality of regional wildlife habitat. An enhancement strategy could be reestablishment of oak woodland in areas away from the stream, and riparian forest near the stream channel. As previously discussed (*in* **Proposed Modifications to Alternative 6**), the area between set-back levees also present opportunities for establishing seasonal wetlands. Woodland habitat, once established, could provide habitat for many vertebrate species, including Swainson's Hawk nest sites. Riparian forest and scrub/shrub habitats established in enclosed areas could mitigate, in part, for unavoidable loss of riparian habitats in other parts of the project area. If the Corps pursues any alternative utilizing set-back levees, the set-back should be far enough from the existing levee so that unlimited vegetation may be allowed between the "old" and new levee without impeding flood-flow conveyance or protection.

2. Set-back Levees on Both Banks

Consider as an enhancement measure set-back levees on both sides of the creek to the extent feasible. This would maximize avoidance of impacts to riparian vegetation adjacent to Cache Creek, and allow a much broader riparian corridor.

3. Fisheries Restoration

Investigate, as an enhancement measure, the reestablishment of fisheries to Cache Creek. The watershed once supported Chinook salmon, American Shad and steelhead trout, but these fisheries disappeared with decreased flows (USFWS 1978). In general, Cache Creek's riverine habitats have been severely degraded due to the cumulative effects of more than a century of water diversions, flood control measures, and conversion of natural habitats to agricultural uses. A critical step in reestablishment of Cache Creek fisheries would be restoration of year-round flows to Cache Creek. This could require substantial changes to water releases from upstream impoundments, changes in water diversions, or development of new water supplies specifically dedicated to fisheries. Such changes could possibly be pursued in concert with the Central Valley Project Improvement Act of 1993, and the State's Anadromous Fisheries Restoration Plan.

4. Management of Exotic Plants

Investigate vegetation management with a primary focus on how to minimize the spread of exotic species, particularly tamarisk and giant reed; if possible, actively work to reduce the areal extent of exotic species and replace them with native riparian trees and shrubs.

5. Use of Low Check Dams to Enhance Riparian Habitat

Explore the possibilities for placement of low check dams as a means of promoting early successional riparian vegetation, and possibly addressing vegetation maintenance requirements. Such dams might be particularly useful if placed just downstream of major road crossings and other channel constrictions, to discourage growth of vegetation with high "roughness" factors near these narrow channel points (USFWS 1993).

Cost Estimates for Future Studies and Mitigation

1. Estimated cost of a HEP: $34,200 (65 biologist days @ $600/day). This cost estimate presented below is based on the Corps' recommended alternative (combination of set-back levees, channel modification, and raising existing levees).
2. Estimated cost of a Draft CAR: $12,000 (20 biologist days @ $600/day).
3. Estimated cost of final CAR: $3,000 (5 biologist days @ $600/day)
4. Estimated cost of biological surveys: $23,400 (39 biologist days @ $600/day). This should be necessary only if an alternative other than the Service's preferred one is chosen. This is because the Service's preferred alternative is configured to minimize biological impact. Other alternatives could have significantly greater biological impacts than the Service's preferred alternative, and assessment of those impacts would require a more detailed knowledge of the area's biological resources.
5. Based on past experience with the Sacramento River Bank Protection Project mitigation, we estimate a mitigation cost of $25,000 per acre to establish riparian vegetation. Monitoring would cost an estimated $10,000 the first year, and $5,000 annually thereafter. Operation and management of a typical mitigation area would cost an estimated $1,000 to $5,000 per year. We estimate land purchases for mitigation would cost between $1,300 and $2,500 per acre for agricultural land.

RECOMMENDATIONS

The riparian habitat corridor along Cache Creek is a highly valuable biological resource; a primary goal of any planned project should be maintenance (and enhancement) of Cache Creek's riparian zone. Although riparian habitat in the proposed project area is currently in a degraded state, it is the best and only riparian habitat in the region, presently supports substantial wildlife populations, and offers future value for habitat restoration and enhancement. The project alternatives as proposed would impact important biological values of the region, notably riparian wetland habitats.

Therefore, the Service recommends that the Corps do the following, should the project go forward to a feasibility study:

1. Adopt the Service's preferred alternative of set-back levees. This would incorporate set-back levees on *both* sides of Cache Creek, to the extent feasible, and would set levees far enough back to permit unlimited vegetation growth between levees and stream channel.

2. Riparian habitat losses should be replaced on-site with in-kind habitat. The continuous linear aspect of riparian habitat along the creek should also be maintained, and, where possible, enhanced.

3. Mitigate for riparian habitat loss due to the project by managing the habitat between set-back levees and stream channel as riparian and seasonal wetland habitats. Incorporate, where feasible, construction of a secondary channel between the existing channel and set-back levees. Also, create a mosaic of depressions of various sizes and depths between the old and new levees, using extracted soil for new levee construction.

4. Fund the Service for biological surveys of the project area, should the Corps chose an alternative other than the Service's preferred alternative. This is because other alternatives could have a significantly greater biological impact, whose assessment would require a more detailed knowledge of the area's resources.

5. Fund the Service for a HEP study and a Fish and Wildlife Coordination Act Report, as part of any feasibility-study process.

6. Complete all aspects of Section 7 of the Endangered Species Act of 1973, as amended, including, but not limited to: (a) obtain, from the Fish and Wildlife Service, an updated Species List for the proposed project area, because the existing one is more than 90 days old; (b) assess the presence of, and impacts to, threatened and endangered species in the project area. This includes all listed species, with particular emphasis on valley elderberry longhorn beetle, giant garter snake, and palmate-bracted bird's-beak.

7. Obtain, prior to the Service beginning a HEP study, detailed aerial photos, preferably color infrared, taken in the spring during the period of maximum vegetation "leaf-out". Photos should be taken at, or enlarged to, a scale of >1:2,000.

8. Consider and identify the indirect effects of the project on development in the floodplain, particularly conversion of agricultural habitat to commercial or residential uses.

9. Investigate the opportunities for enhancement of the wildlife values along Cache Creek, including but not limited to: (a) restoration of anadromous fisheries to Cache Creek, (b) management of exotic species in the stream channel, and (c) use of passive systems such as low check-dams to manage vegetation where necessary, such as where the channel narrows at bridges.

10. Provide maps which clearly identify the geographical limits of flooding under different flows. The maps provided to date show the limit of flooding for only 500-year events. Information on extent of flooding under more frequent flooding events would be valuable in assessing losses of floodplain areas due to the project.

11. Consult with the California Natural Diversity Database to obtain data on presence of resources of special concern in the study area; 90 occurrences are known from the three 7.5-minute topographic maps which include the study area. All requirements of the California State Endangered Species Act should be met, including, but not limited to: assessing the presences of, and impacts to, state-listed species. This includes all listed species, including Swainson's hawks.

12. Explore "nonstructural" alternatives, in which areas or structures with high value would be individually protected, while other areas, such as agricultural lands, would be allowed to flood, as has occurred historically, and which in the past has been compatible with agricultural land uses.

13. Determine the effects of the project on mercury levels in the Cache Creek system. Sediment core samples should be collected and analyzed where project work would include disturbances to stream deposits; sampling should concentrate on depositional areas. These samples should be analyzed, to fully assess possible mercury contamination and the potential for mercury remobilization, prior to initiating work in the stream channel. Disturbance to sediments is particularly, but not exclusively, a concern with stream channelization.

LITERATURE CITED

Borcalli and Associates. 1994. Westside Tributaries to Yolo Bypass Investigation Basis of Design and Cost Estimates (draft). Prepared for Corps of Engineers, Sacramento, CA.

Department of the Army. 1979. Cache Creek Basin, California: Feasibility Report and Environmental Statement for Water Resources Development. Corps of Engineers, Sacramento District.

Department of the Army. 1992. Reconnaissance Report, Yolo Bypass, California. Corps of Engineers, Sacramento District.

Hynson, J.R., Adamus, P.R., Elmer, J.O., and T. DeWan. 1985. Environmental Features for Streamside Levee Projects. Environmental and Water Quality Operational Studies. Tech. Report E-85-7. Department of Army, US Army Corps of Engineers, Vicksburg, Mississippi.

Jameson, E.W. Jr., and H.J. Peeters. 1988. California Mammals. University of Calif. Press, Berkeley.

Madrone Associates, B.E. Jones, D.W. Kelly, Storm Engineering, and J.R. Arnold. 1980. Sacramento/San Joaquin Delta wildlife habitat protection and restoration plan. Report for Calif. Dept. Fish and Game and U.S. Fish and Wildlife Service.

Opler, P.A. 1974. Oaks as evolutionary islands for leaf-mining insects. Amer. Scientist 62:67-73.

Rieger, J.P. and D. A. Kreager. 1989. Giant Reed (*Arundo donax*): A climax community of the riparian zone. Pp. 222-225 *in*: Proceedings of the California Riparian Systems Conference. USDA Forest Service Gen. Tech. Rep. PSW-110, Pacific Southwest Forest and Range Experimental Station, Berkeley, California.

Simpson, P.W., Newman, J.R., Keirn, M.A., Matter, R.M., and P.A. Guthrie. 1982. Manual of Stream Channelization Impacts on Fish and Wildlife. Biological Services Program Publication FWS/OBS-82/24. Fish and Wildlife Service, U.S. Dept. of Interior, Washington, D.C.

Thompson, K. 1961. Riparian forests of the Sacramento Valley, California. Annals Assoc. Amer. Geographers 51:294-315.

U.S. Fish and Wildlife Service. 1978. Cache Creek Basin, California: A Detailed Report on Fish and Wildlife Resources. Sacramento Field Office.

U.S. Fish and Wildlife Service. 1991a. Federal Register, Vol. 56, No. 249. Proposed Endangered Status for the Giant Garter Snake. FWE Field Office, Sacramento, CA. 7 pgs.

U.S. Fish and Wildlife Service. 1991b. The Distribution, Habitat, and Status of the Valley Elderberry Longhorn Beetle. FWE Field Office, Sacramento, CA.

U.S. Fish and Wildlife Service. 1993. Reconnaissance Planning Report: Fish and Wildlife Options for Lower Putah Creek, California. Ecological Services Field Office, Sacramento, CA

U.S. Geological Survey. 1992. Water Resources Data, California, Water Year 1991, Vol. 4: Northern Central Valley Basins and the Great Basin from Honey Lake to Oregon State Line. USGS Water-data Report CA-91-4.

Verner, J. 1980. Birds of California oak habitats--management implications. Pp. 246-263 *in* Plumb, T.R. Ecology, Management, and utilization of California oaks. USDA Forest Service Gen. Tech. Report PSW-37. Pacific Southwest Forest and Range Experimental Station, Berkeley, CA

Zentner and Zentner. 1993. Cache Creek Environmental Restoration Program, Yolo County, California.

APPENDIX A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES THAT MAY OCCUR IN THE AREA OF THE PROPOSED WESTSIDE TRIBUTARIES TO THE YOLO BYPASS RECONNAISSANCE STUDY, YOLO COUNTY, NORTHERN CALIFORNIA
(1-1-93-SP-1504, OCTOBER 26, 1993)

Listed Species

Reptiles
giant garter snake, *Thamnophis gigas* (T)

Birds
bald eagle, *Haliaeetus leucocephalus* (E)

Invertebrates
valley elderberry longhorn beetle, *Desmocerus californicus dimorphus* (T)

Plants
palmate-bracted bird's-beak, *Cordylanthus palmatus* (E)

Proposed Species

None

Candidate Species

Fish
Sacramento splittail, *Pogonichthys macrolepidotus* (2*)

Amphibians
California tiger salamander, *Ambystoma californiense* (2*)
western spadefoot toad, *Scaphiopus hammondi hammondi* (2R)
foothill yellow-legged frog, *Rana boylei* (2)

Reptiles
northwestern pond turtle, *Clemmys marmorata marmorata* (2)

Birds
tricolored blackbird, *Agelaius tricolor* (2)
mountain plover, *Charadrius montanus* (2)
loggerhead shrike, *Lanius ludovicianus* (2)

Mammals
Pacific western big-eared bat, *Plecotus townsendii townsendii* (2)
greater western mastiff-bat, *Eumops perotis californicus* (2)
San Joaquin Valley woodrat, *Neotoma fuscipes riparia* (2)

Plants

recurved larkspur, *Delphinium recurvatum* (2)
adobe lily, *Fritillaria pluriflora* (2)
Brewer's dwarf-flax, *Hesperolinon breweri* (2)
California hibiscus, *Hibiscus californicus* (2)
Hinds' walnut, *Juglans hindsii* (2)
Contra Costa goldfields, *Lasthenia conjugens* (1)
few-flowered navarretia, *Navarretia pauciflora* (2)
Gairdner's yampah, *Perideridia gairdneri ssp. gairdneri* (2)

(E)--Endangered (T)--Threatened (P)--Proposed (CH)--Critical Habitat
(1)--Category 1: Taxa for which the Fish and Wildlife Service has sufficient biological information to support a proposal to list as endangered or threatened.
(2)--Category 2: Taxa for which existing information indicated may warrant listing, but for which substantial biological information to support a proposed rule is lacking.
(1R)-Recommended for Category 1 status.
(2R)-Recommended for Category 2 status.
(•)--Listing petitioned.
(*)--Possibly extinct.

APPENDIX B

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7(a) and (c) OF THE ENDANGERED SPECIES ACT

SECTION 7(a) Consultation/Conference

Requires: 1) Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species; 2) Consultation with FWS when a Federal action may affect a listed endangered or threatened species to insure that any action authorized, funded or carried out by a Federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the Federal agency after determining the action may affect a listed species; and 3) Conference with FWS when a Federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat.

SECTION 7(c) Biological Assessment--Major Construction Activity[1]

Requires Federal agencies or their designees to prepare a Biological Assessment (BA) for major construction activities. The BA analyzes the effects of the action[2] on listed and proposed species. The process begins with a Federal agency requesting from FWS a list of proposed and listed threatened and endangered species. The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the list, the accuracy of the species list should be informally verified with our Service. No irreversible commitment of resources is to be made during the BA process which would foreclose reasonable and prudent alternatives to protect endangered species. Planning, design, and administrative actions may proceed; however, no construction may begin.

We recommend the following for inclusion in the BA: an on-site inspection of the area affected by the proposal which may include a detailed survey of the area to determine if the species or suitable habitat are present; a review of literature and scientific data to determine species' distribution, habitat needs, and other biological requirements; interviews with experts, including those within FWS, State conservation departments, universities and others who may have data not yet published in scientific literature; an analysis of the effects of the proposal on the species in terms of individuals and populations, including consideration of indirect effects of the proposal on the species and its habitat; an analysis of alternative actions considered. The BA should document the results, including a discussion of study methods used, any problems encountered, and other relevant information. The BA should conclude whether or not a listed or proposed species will be affected. Upon completion, the BA should be forwarded to our office.

---

[1] A construction project (or other undertaking having similar physical impacts) which is a major Federal action significantly affecting the quality of the human environment as referred to in NEPA (42 U.S.C. 4332(2)C).

[2] "Effects of the action" refers to the direct and indirect effects on an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action.

APPENDIX C: Letter to California Fish and Game Department, requesting information on state-listed species in the study area.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825-1846

February 23, 1994

Bryan Broddrick
Regional Manager
California Department of Fish and Game
1701 Nimbus Road, Suite A
Rancho Cordova, California 95670

Subject: CESAC-Yolo Bypass Westside Tributaries Reconnaissance Study

Dear Mr. Broddrick:

The Corps of Engineers (Corps) is conducting a reconnaissance study to evaluate flood problems and potential solutions along Cache Creek in Yolo County. The study will determine the potential for Federal participation in the development and construction of flood control measures for a portion of the Cache Creek watershed.

The Fish and Wildlife Service (Service) has been requested to provide a planning aid report discussing potential impacts to fish and wildlife resources, including State and federally-listed threatened and endangered species. We request your Department's assistance by providing a list of State-listed threatened and endangered species, and species of special concern for inclusion in our report.

The area which may be affected by the project includes Cache Creek between County Road 94B (downstream of the Highway 505 crossing) and the Cache Creek Settling Basin, near County Road 102. The project alternatives include channel improvements, levee raising, and construction of set-back levees.

The Service's draft report is due to the Corps on March 1, with a final due 15 March, 1994. Therefore, we would appreciate receipt of the above information as soon as possible so that it can be incorporated into the report.

Our draft report will be sent to you for review comments. If you have any questions regarding this request, please contact Gary Falxa of my staff at (916) 978-5606.

Sincerely,

for Dale A. Pierce
Acting Field Supervisor

cc: ARD, ES, FWS, Portland, OR

APPENDIX B

COMMON AND SCIENTIFIC NAMES OF SPECIES DISCUSSED IN THE EE

Table - List of Common and Scientific Names of Fish and Wildlife that could occur in the Project Area.

BIRDS

Common Name	Scientific Name
American bittern	*Botaurus lentiginosus*
American peregrine falcon	*Falco peregrinus anatum*
American kestrel	*Falco sparverius*
bald eagle	*Haliaeetus leucocephalus*
bank swallow	*Riparia riparia*
barn owl	*Tyto alba*
black-crowned night-heron	*Nycticorax nycticorax*
black-shouldered kite	*Elanus caeruleus*
bushtit	*Psaltriparus minimus*
California quail	*Callipepla californica*
common flicker	*Colaptes auratus*
common yellowthroat	*Geothlypis trichas*
downy woodpecker	*Picoides pubescens*
ferruginous hawks	*Buteo regalis*
great blue heron	*Ardea herodias*
great egret	*Casmerodius albus*
kingfisher	*Megaceryle alcyon*
loggerhead shrike	*Lanius ludovicianus*
marsh wren	*Cistothorus palustris*
mountain plover	*Charadrius montanus*
Nuttall's woodpecker	*Picoides nuttallii*
red-shouldered hawk	*Buteo lineatus*
red-winged blackbird	*Agelaius phoenicus*
rough-legged hawk	*Buteo lagopus*
snowy egret	*Egretta thula*
Swainson's hawk	*Buteo swainsoni*
tricolored blackbird	*Agelaius tricolor*
western meadowlark	*Sturnella neglecta*
Western snowy plover	*Charadrius alexandrinus nivosus*
Western yellow billed cuckoo	*Coccyzus americanus occidentalis*
White faced ibis	*Plegadis chihi*
white-crowned sparrow	*Zonotrichia leucophrys*

MAMMALS

Common Name	Scientific Name
beavers	*Castor canadensis*
coyotes	*Canis latrans*
deer	*Odocoileus hemionus*
greater western mastiff-bat	*Eumops perotis californicus*
muskrat	*Ondatra zibethicus*
Pacific western big-eared bat	*Plecotus townsendii townsendii*
pocket gophers	*Thomomys bottae*
raccoons	*Procyon lotor*
red fox	*Vulpes vulpes*
San Joaquin Valley woodrat	*Neotoma fuscipes riparia*
voles	*Microtus californicfus*
western gray squirrel	*Sciurus griseus*

REPTILES

Common Name	Scientific Name
giant garter snake	*Thamnophis sp.*
northwestern pond turtle	*Clemmys marmorata marmorata*

AMPHIBIANS

Common Name	Scientific Name
bullfrog	*Rana catesbeiana*
California tiger salamander	*Ambystoma californiense*
foothill yellow-legged frog	*Rana boylei*
Pacific treefrog	*Hyla regilla*
Western spadefoot toad	*Scaphiopus hammondi hammondi*

FISH

Common Name	Scientific Name
Sacramento splittail	*Pogonichthys macrolepidotus*

INVERTEBRATE

Common Name	Scientific Name
valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*

Table - List of Common and Scientific Names of Plants that could occur in the Project Area.

WOODY PLANTS

Common Name	Scientific Name
baccharis	*Baccharis sp.*
blackberry	*Rubus sp.*
California hibiscus	*Hibiscus californicus*
cottonwood	*Populus fremontii*
elderberry	*Sambucus mexicana*
Hinds' walnut	*Juglans hindsii*
locust	*Robinia pseudo-acacia*
poison oak	*Toxicodendron diversilobum*
tamarisk	*Tamarix sp.*
valley oak	*Quercus lobata*
wild grape	*Vitis californica*
wild rose	*Rosa sp.*
willow	*Salix spp.*

HERBACEOUS PLANTS (EXCLUDING GRASSES)

Common Name	Scientific Name
adobe lily	*Fritillaria pluriflora*
Brewer's dwarf-flax	*Hesperolinon breweri*
cattails	*Typha sp.*
Contra Costa goldfields	*Lasthenia conjugens*
Ferris' Bird's-beak	*Cordylanthus palmatus*
few-flowered navarettia	*Navarettia pauciflora*
Gairdner's yamphah	*Perideridia gairdneri ssp. gairdneri*
horehound	*Marrubium vulgare*
milk thistle	*Silybum marianum*
palmate-bracted bird's-beak	*Cordylanthus palmatus*
poison oak	*Toxicodendron diversiloba*
recurved larkspur	*Delphinium recurvatum*
rushes	*Juncus sp.*
San Joaquin saltbush	*Atriplex joaquiniana*
sedges	*Cyperus sp.*
star thistle	*Centaurea sp.*
teasel	*Dipsacus sp.*
tules	*Scirpus acutus*
yellow star-thistle	*Centaurea solstitialis*

GRASSES

Common Name	Scientific Name
barley	*Hordeum leporinum*
brome	*Bromus diandrus*
Italian ryegrass	*Lolium multiflorum*
wild oats	*Avena fatua*

APPENDIX C

ENDANGERED SPECIES COORDINATION

CORPS OF ENGINEERS
1325 J STREET
SACRAMENTO, CALIFORNIA 95814-2922

REPLY TO
ATTENTION OF

September 9, 1993

Environmental Resources Branch

Gary Matlock, Ph.D.
Acting Regional Director
National Marine Fisheries Service
300 South Ferry Street
Terminal Island, California 90731-7415

Dear Dr. Matlock:

We are preparing an environmental evaluation for the Westside Tributaries to the Yolo Bypass Reconnaissance Study. Pursuant to Section 7(c) of the Endangered Species Act, we request that you advise us whether any Federally protected species under your jurisdiction may be present in the study area.

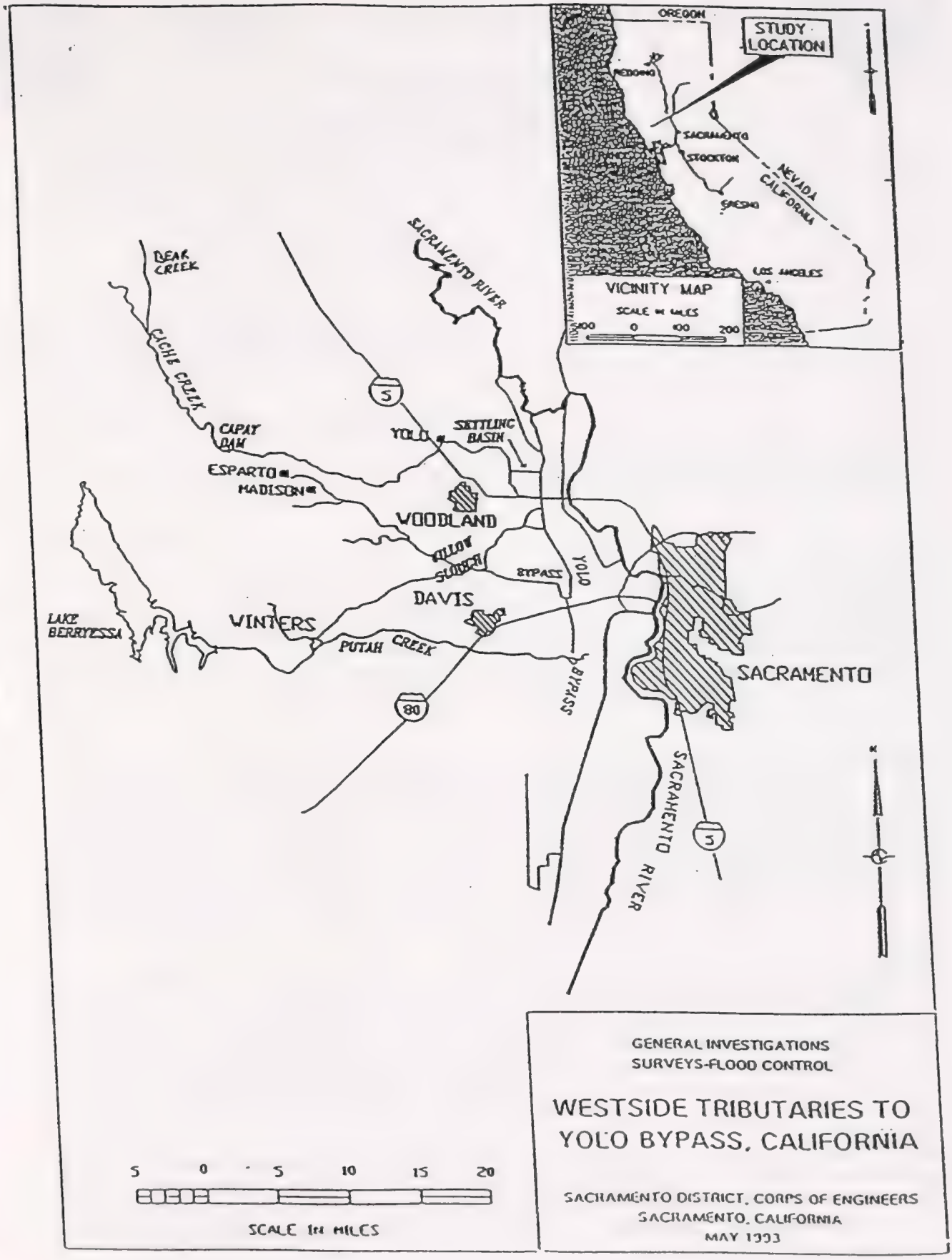
The purpose of the Westside Tributaries to the Yolo Bypass Reconnaissance Study is to determine the potential for Federal participation in increasing levels of flood protection along the westside tributaries to the Yolo Bypass, from Cache Creek in the north to South Fork Putah Creek in the south (map enclosed). An additional purpose is to identify restoration needs and opportunities within the study area. The study area includes the lower reaches of Bear Creek (tributary to Cache Creek), Cache Creek, Willow Slough, Dry Slough (part of Willow Slough system), and Putah Creek (from just below Lake Berryessa). Flood control techniques under consideration are: (1) levee raising, (2) channel excavation, (3) detention basins, and/or (4) non-structural measures, such as individual floodwalls or ring levees.

Please provide us with your response to this letter within 30 days. If you have any questions please contact Tanis Toland (916/557-6717).

Sincerely,

Walter Yep
Chief, Planning Division

Enclosure



GENERAL INVESTIGATIONS
SURVEYS-FLOOD CONTROL

WESTSIDE TRIBUTARIES TO YOLO BYPASS, CALIFORNIA

SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA
MAY 1993

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825-1846

TAKE PRIDE IN AMERICA

In Reply Refer To:
1-1-93-SP-1504

October 26, 1993

Mr. Walter Yep
Chief, Planning Division
U.S. Army Engineer District, Sacramento
Corps of Engineers
1325 J Street
Sacramento, California 95814-2922

Subject: Species List for the Proposed Westside Tributaries to the Yolo Bypass Reconnaissance Study, Yolo County, Northern California

Dear Mr. Yep:

As requested by letter from your agency dated September 9, 1993, you will find enclosed a list of the listed endangered and threatened species that may be present in the subject project area (see Enclosure A). To the best of our knowledge, no proposed species occur within the ß≥ea. This list fulfills the requirement of the Fish and Wildlife Service (Service) to provide a species list pursuant to section 7(c) of the Endangered Species Act, as amended, (Act).

Some pertinent information concerning the distribution, life history, habitat requirements, and published references for the listed species is also enclosed. This information may be helpful in preparing the biological assessment for this project, if one is required. Please see Enclosure B for a discussion of the responsibilities Federal agencies have under section 7(c) of the Act and the conditions under which a biological assessment must be prepared by the lead Federal agency or its designated non-Federal representative.

Formal consultation, pursuant to 50 CFR § 402.14, should be initiated if you determine that a listed species may be affected by the proposed project. Informal consultation may be utilized prior to a written request for formal consultation to exchange information and resolve conflicts with respect to a listed species. If a biological assessment is required, and it is not initiated within 90 days of your receipt of this letter, you should informally verify the accuracy of this list with our office.

Also, for your consideration, we have included a list of the candidate species that may be present in the project area (see Enclosure A). These species are currently being reviewed by the Service and are under consideration for possible listing as endangered or threatened. Candidate species have no

protection under the Act, but are included for your consideration as it is possible that one or more of these candidates could be proposed and listed before the subject project is completed. Should the biological assessment reveal that candidate species may be adversely affected, you may wish to contact our office for technical assistance. One of the potential benefits from such technical assistance is that by exploring alternatives early in the planning process, it may be possible to avoid conflicts that could otherwise develop, should a candidate species become listed before the project is completed.

Please contact Laurie Stuart Simons of this office at 916/978-4866 if you have any questions regarding the enclosed list or your responsibilities under the Act.

Sincerely,

Cay C. Goude

for Dale A. Pierce
Acting Field Supervisor

Enclosures

ENCLOSURE A

LISTED AND PROPOSED ENDANGERED AND THREATENED SPECIES AND CANDIDATE SPECIES THAT MAY OCCUR IN THE AREA OF THE PROPOSED WESTSIDE TRIBUTARIES TO THE YOLO BYPASS RECONNAISSANCE STUDY, YOLO COUNTY, NORTHERN CALIFORNIA (1-1-93-SP-1504, OCTOBER 26, 1993)

Listed Species

Reptiles
giant garter snake, *Thamnophis gigas* (T)

Birds
bald eagle, *Haliaeetus leucocephalus* (E)

Invertebrates
valley elderberry longhorn beetle, *Desmocerus californicus dimorphus* (T)

Plants
palmate-bracted bird's-beak, *Cordylanthus palmatus* (E)

Proposed Species

None

Candidate Species

Fish
Sacramento splittail, *Pogonichthys macrolepidotus* (2▪)

Amphibians
California tiger salamander, *Ambystoma californiense* (2▪)
western spadefoot toad, *Scaphiopus hammondi hammondi* (2R)
foothill yellow-legged frog, *Rana boylei* (2)

Reptiles
northwestern pond turtle, *Clemmys marmorata marmorata* (2)

Birds
tricolored blackbird, *Agelaius tricolor* (2)
mountain plover, *Charadrius montanus* (2)
loggerhead shrike, *Lanius ludovicianus* (2)

Mammals
Pacific western big-eared bat, *Plecotus townsendii townsendii* (2)
greater western mastiff-bat, *Eumops perotis californicus* (2)
San Joaquin Valley woodrat, *Neotoma fuscipes riparia* (2)

Plants

recurved larkspur, *Delphinium recurvatum* (2)
adobe lily, *Fritillaria pluriflora* (2)
Brewer's dwarf-flax, *Hesperolinon breweri* (2)
California hibiscus, *Hibiscus californicus* (2)
Hinds' walnut, *Juglans hindsii* (2)
Contra Costa goldfields, *Lasthenia conjugens* (1)
few-flowered navarretia, *Navarretia pauciflora* (2)
Gairdner's yampah, *Perideridia gairdneri ssp. gairdneri* (2)

(E)--Endangered (T)--Threatened (P)--Proposed (CH)--Critical Habitat
(1)--Category 1: Taxa for which the Fish and Wildlife Service has sufficient biological information to support a proposal to list as endangered or threatened.
(2)--Category 2: Taxa for which existing information indicated may warrant listing, but for which substantial biological information to support a proposed rule is lacking.
(1R)-Recommended for Category 1 status.
(2R)-Recommended for Category 2 status.
(▪)--Listing petitioned.
(*)--Possibly extinct.

ENCLOSURE B

FEDERAL AGENCIES' RESPONSIBILITIES UNDER SECTIONS 7(a) and (c) OF THE ENDANGERED SPECIES ACT

SECTION 7(a) Consultation/Conference

Requires: 1) Federal agencies to utilize their authorities to carry out programs to conserve endangered and threatened species; 2) Consultation with FWS when a Federal action may affect a listed endangered or threatened species to insure that any action authorized, funded or carried out by a Federal agency is not likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat. The process is initiated by the Federal agency after determining the action may affect a listed species; and 3) Conference with FWS when a Federal action is likely to jeopardize the continued existence of a proposed species or result in destruction or adverse modification of proposed critical habitat.

SECTION 7(c) Biological Assessment--Major Construction Activity[1]

Requires Federal agencies or their designees to prepare a Biological Assessment (BA) for major construction activities. The BA analyzes the effects of the action[2] on listed and proposed species. The process begins with a Federal agency requesting from FWS a list of proposed and listed threatened and endangered species. The BA should be completed within 180 days after its initiation (or within such a time period as is mutually agreeable). If the BA is not initiated within 90 days of receipt of the list, the accuracy of the species list should be informally verified with our Service. No irreversible commitment of resources is to be made during the BA process which would foreclose reasonable and prudent alternatives to protect endangered species. Planning, design, and administrative actions may proceed; however, no construction may begin.

We recommend the following for inclusion in the BA: an on-site inspection of the area affected by the proposal which may include a detailed survey of the area to determine if the species or suitable habitat are present; a review of literature and scientific data to determine species' distribution, habitat needs, and other biological requirements; interviews with experts, including those within FWS, State conservation departments, universities and others who may have data not yet published in scientific literature; an analysis of the effects of the proposal on the species in terms of individuals and populations, including consideration of indirect effects of the proposal on the species and its habitat; an analysis of alternative actions considered. The BA should document the results, including a discussion of study methods used, any problems encountered, and other relevant information. The BA should conclude whether or not a listed or proposed species will be affected. Upon completion, the BA should be forwarded to our office.

---

[1] A construction project (or other undertaking having similar physical impacts) which is a major Federal action significantly affecting the quality of the human environment as referred to in NEPA (42 U.S.C. 4332(2)C).

[2] "Effects of the action" refers to the direct and indirect effects on an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213
TEL (310) 980-4000; FAX (310) 980-4018

F/SW031:GJB

OCT 07 1993

Mr. Walter Yep
Chief, Planning Division
Corps of Engineers
1325 J Street
Sacramento, CA 95814-2922

Dear Mr. Yep:

Thank you for requesting information regarding the presence of Federally listed threatened or endangered species or critical habitat that may be affected by the Yolo Bypass Reconnaissance Study. The site is located outside the designated critical habitat for winter-run chinook salmon (58 FR 33212). However, the Federally listed threatened winter-run chinook salmon may occur seasonally within the proposed project site. No additional species under the management authority of the National Marine Fisheries Service occur at the proposed project site. However, the U.S. Fish and Wildlife Service should be contacted regarding the presence of listed species that may be under its jurisdiction.

If you have questions concerning these comments, please contact Mr. Greg Bryant at (707) 578-7513.

Sincerely,

for Gary Matlock, Ph.D.
Acting Regional Director

APPENDIX D

CALIFORNIA NATURAL DIVERSITY DATA BASE

The Natural Diversity Data Base (NDDB)

The Natural Diversity Data Base (NDDB) is a statewide manual and computerized inventory of locational information on California's rare and endangered species and natural biotic communities. Established by State Legislation in 1982, the NDDB is patterned after other natural heritage programs which were originally created by the Nature Conservancy. The NDDB is managed by the California Department of Fish and Game. Officially listed (State and Federal) endangered, threatened, and rare animals and plants, plus those considered by the scientific community to be deserving of such listing, are included in the NDDB. Information in the NDDB comes primarily from scientific literature, herbaria and natural history museum collections, universities, volunteers with the California Native Plant Society and the Audubon Society, Nature Conservancy, and biologists from many other agencies and organizations. Information in the NDDB is continually updated (DFG 1986).

APPENDIX E

LETTERS OF COMMENT ON THE NOTICE OF INITIATION

We Appreciate Your Comments on the Westside Tributaries to Yolo Bypass, California

WRITE OR CALL:
(916) 557-6755

Do we have your correct mailing address? ~~If not,~~ enter the correct one in the space provided.

Name ROSWITA NORRIS
Address 25112 CENTRAL WAY
City DAVIS
State CA Zip 95616

COMMENTS OR ADDITIONAL ADDRESSES

(1) DURING THIS SPRING OF 1993, OUR GARAGE HAD WATER RUNNING THROUGHT AND THE CRAWL SPACE UNDER OUR HOUSE ALSO HAD WATER COURSING OVER IT. WE HAVE LIVED IN THIS HOUSE SINCE 1969 AND HAVE NEVER BEEN FLOODED BEFORE — SO WHY THIS YEAR? 2 POSSIBILITIES ARE PUT FORTH — ONE: DEVELOPEMENT OF WEST DAVIS, NORTH DAVIS, HWY 113 CONVERSION INTO A FREEWAY AND NEW HOUSING & DRAINAGE AROUND THE MUNICIPAL GOLF COURSE (i "developement") and TWO: THE FARMERS TO THE WEST AND TO THE NORTH OF US DID NOT PUT IN PROPER DRAINAGE DITCHES (PERHAPS THE DROUGHT LET THEM FORGET THAT THESE DITCHES NEED TO HAVE A CERTAIN DEPTH AND BREADTH TO THEM — CAN THE COUNTY OR THE CORP OF E. REAQUAINT THE FARMERS WITH PROPER DRAINAGE DITCHES). PERHAPS YOU CAN ALSO LET ME KNOW OF ANY ~~OTHER~~ REASONS FOR OUR FLOODING. PLEASE NOTE: WHILE WE WERE FLOODING I DROVE UP TO THE MUNICIPAL GOLFCOURSE EXPECTING WORSE FLOODS THERE THAN WITH US, BECAUSE IN THE PAST, THE GOLF COURSE AREA COULD QUITE EASILY HAVE 6-12" OF WATER OVER IT (IN PLACES) WHILE WE JUST HAD 1"-2" OF WATER IN THE STREET. HOWEVER THIS YEAR THE GOLF COURSE WAS DRY WHILE WE WENT UNDER. ARE YOU SURPRISED IF I AM SUSPICIOUS THAT THEIR NEW DRAINAGE SYSTEM MIGHT HAVE CAUSED US TO FLOOD?

TO MAIL: FOLD AND SEAL OR STAPLE EDGE.

(2) I AM VERY CONCERNED THAT THE "NEW" SUTTER DAVIS HOSPITAL POND & PUMPING SYSTEM IS ONLY GOING TO BACK UP THE WATER EVEN MORE TO WHERE WE LIVE. THEIR DIAGRAMS ~~AND~~ etc. DID NOT LOGICALLY CONVINCE THAT THEY WOULD NOT FLOOD US.

We Appreciate Your Comments on the Westside Tributaries to Yolo Bypass, California

WRITE OR CALL:
(916) 557-6755

Do we have your correct mailing address? If not, enter the correct one in the space provided.

Name _____

Address _____

City _____

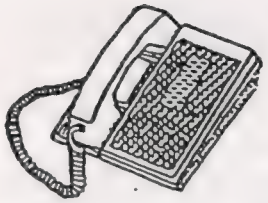
State _____ Zip _____

COMMENTS OR ADDITIONAL ADDRESSES

The Army Corps of Engineer has a suspicious reputation. I've seen only one instance of flood — the Benning tract by Highway 113 & the 2 homes right south of the golf course by 113. I've never seen flooding in Woodland.

TO MAIL: FOLD AND SEAL OR STAPLE EDGE.

We Appreciate Your Comments on the Westside Tributaries to Yolo Bypass, California



WRITE OR CALL:
(916) 557-6755

Do we have your correct mailing address? If not, enter the correct one in the space provided.

Name David Magaw, President
Address 3344 Braeburn St.
City Sacramento
State CA Zip 95821-4037

COMMENTS OR ADDITIONAL ADDRESSES

Yolo Shortline Railroad Co.

We own land and the railroad trestle just N. of I-5 the Yolo Bypass. We have concerns regarding the changing flows in the Bypass from Cache creek, the new settleing basin, and drainage from the City of Woodland. We have been working with RD 2035 and DWR regarding water flow problems in this area. Please put us on your mailing list and keep us informed of any plans, programs or developments affecting this area.

TO MAIL: FOLD AND SEAL OR STAPLE EDGE

Westside Tributaries to
Yolo Bypass, California

WRITE OR CALL:
(916) 557-6755

Do we have your correct mailing address? If not, enter the correct one in the space provided.

Name [redacted]
Address
City
State Zip

COMMENTS OR ADDITIONAL ADDRESSES

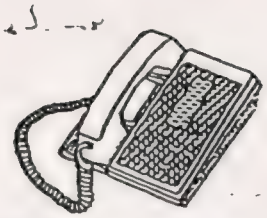
THIS RECONNAISSANCE LEVEL STUDY SHOULD INCLUDE PUTAH CREEK & DRY CREEK IN THE WINTERS AREA.

ANALYSIS IS CURRENTLY BEING CONDUCTED BY NORTE ENGINEERS FOR MOODY SLOUGH; DRY CREEK & PUTAH CREEK IN THE WINTERS AREA — THIS EFFORT SHOULD BE FOLDED INTO THE WORK UNDER WAY AT THE CORPS.

ROBERT MACMICHAEL, COMMUNITY DEVEL. DIRECTOR
CITY OF WINTERS
318 FIRST ST
WINTERS, 95694

TO MAIL: FOLD AND SEAL OR STAPLE EDGE.

Westside Tributaries to
Yolo Bypass, California



WRITE OR CALL:
(916) 557-6755

Do we have your correct mailing address? If not, enter the correct one in the space provided.

Name Marjorie Rhinehart Way
Address 650 Peartree Dr.
City Watsonville
State CA Zip 95076

COMMENTS OR ADDITIONAL ADDRESSES

I plan on continuing farming my property at RD #24 and RD #105. I was pleased to see there was no great amount of flooding on my property this past winter.

Marjorie Rhinehart Way

TO MAIL: FOLD AND SEAL OR STAPLE EDGE.

APPENDIX B

HYDROLOGY REPORT

HYDROLOGY OF THE WESTSIDE TRIBUTARIES OF THE YOLO BYPASS, CALIFORNIA

RECONNAISSANCE STUDY

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

CONTENTS

Subject	Page
Purpose of Study	1
Discussion	1
Cache Creek Basin	1
Putah Creek Basin	1
Willow Slough Basin	2
Basin Description	2
Cache Creek Basin	2
Putah Creek Basin	3
Willow Slough Basin	3
Climate	4
Cache Creek Basin	4
Putah Creek Basin	5
Willow Slough Basin	6
Runoff	6
Cache Creek Basin	6
Putah Creek Basin	7
Willow Slough Basin	8
Flood Problems	8
Historical Flooding	8
Cache Creek Basin	8
Putah Creek Basin	10
Willow Slough Basin	10
Hydrologic Analysis	11
Cache Creek	11
General	11
Storm Analysis	11
Baseflow	11
Unit Hydrograph	11
Loss Analysis	12
Routing Parameters	12
Flow Frequency	12
Risk Analysis	13
Flood Hydrographs	13
Putah Creek	13
Flood Analysis	13
Flow Frequency Analysis	13
Normal Depth Calculations	14
Willow Slough Basin	14
HEC-1 Model	14
References	16

TABLES

Table Number		Page
I	Cache Creek Basin Climatic Data	4
II	Putah Creek Basin Climatic Data	5
III	Willow Slough Basin Climatic Data	6
IV	Cache Creek Basin Stream Gaging Stations	7
V	Putah Creek Basin Stream Gaging Stations	8
VI	Peak Flow and Volume Data of Record Cache Creek Basin	9
VII	Peak Flow and Volume Data of Record Putah Creek at Winters	10
VIII	Unit Hydrograph Information Bear Creek Basin	12
IX	Willow Slough Basin 10-year 800 cfs Limits	15
X	Willow Slough Basin 100-year 1800 cfs Limits	15

CHARTS

Chart Number

1 General Map, Cache Creek Basin

2 General Map, Putah Creek Basin

3 General Map, Willow Slough Basin

4 Routing Diagram, Cache Creek Basin

5 Cache Creek at Capay, Peak Flow Frequency Curve

6 Putah Creek at Winters, Peak Flow Frequency Curve

7 Cache Creek at Capay, 100-Year Flood Hydrograph Index 10

8 Cache Creek at Capay, 200-Year Flood Hydrograph Index 10

9 Cache Creek at Capay, 500-(SPF) Year Flood Hydrograph Index 10

Purpose of Study

The purpose of the study was to evaluate potential flood problems of the Westside Tributaries to the Yolo Bypass, specifically in the vicinity of Woodland and Davis. The study focused on upstream reaches of Cache Creek to the north, Willow Slough in the mid-section, and Putah Creek to the south. Existing hydrologic data for the Cache Creek basin and the Cache Creek HEC-1 model were to be updated. The 100-, 200-, and 500-year flood hydrographs were to be computed for a proposed detention basin site on Bear Creek (tributary to Cache Creek) and for Cache Creek at Capay. The detention basin was proposed as one of the alternatives to alleviate flooding in the reach of Cache Creek below Capay. The streams in the Willow Slough Basin were to be evaluated to determine where the 10-year/800 cubic feet per second and 100-year/1800 cfs locations were to determine Federal interest. These locations were needed to investigate the flooding problems of the Willow Slough Basin from the outer reaches of the basin to those locations that exist in and around the City of Davis. Putah Creek was to be studied to evaluate the capacity of the Putah Creek diversion channel and whether the Putah Creek could contain the 100-year peak flow event and if the City of Davis would be flooded during this event.

Discussion

Cache Creek Basin

Previous studies on Cache Creek were reviewed. The recorded flow and volume data records at the gaging station locations for Cache Creek Basin were updated statistically. For this study, because the Capay gage was discontinued in 1984, the length of record did not change, and the regulated peak flow frequency curve for Cache Creek at Capay from reference 1 was used. In order for a risk-based analysis to be conducted, sample statistics of the regulated peak flow data needed to be calculated in order to develop a distribution of uncertainty for the range of exceedence probabilities associated with the sample statistics. The Cache Creek HEC-1 model was used to compute the 100-, 200-, and 500-year basin flood hydrographs for the existing conditions at the proposed Bear Creek detention basin site and for Cache Creek at Capay. These were needed in future studies to evaluate the consequences of flooding downstream of Capay and the effects of the flood protection alternatives. The peak flows were verified with the Capay peak flow frequency curve.

Putah Creek Basin

Previous studies on Putah Creek were reviewed; and hydrologic data were updated. For Putah Creek, a graphical peak flow frequency curve using the updated flow records for Putah Creek at Winters was developed using Bulletin 17B criteria and U.S. Army Corps of Engineers criteria. The peak discharge and historical stage of the March 2, 1983, event for Putah Creek at Old Davis Road were used to compute the water surface elevation for the 100- year

event. This was compared to the available levee height at Old Davis Road to see
whether Putah Creek could contain the 100 year event within channel and prevent the City of Davis from flooding.

Willow Slough Basin

A cursory review of the Willow Slough HEC-1 model (developed by the engineering firm of Borcalli and Associates) was conducted to determine which section of the streams complied with the 10-year/800 and 100-year/1800 cfs U.S Army Corps of Engineers criteria to evaluate the flooding problems in and around the City of Davis.

Basin Description

Cache Creek Basin

Cache Creek basin is located about 100 miles northeast of San Francisco in the coastal mountain ranges. Its predominant feature is Clear Lake, the largest natural body of fresh water entirely within the State of California. Cache Creek and Lake drain about 1,139 square miles of area. See chart 1. The outlet of Clear Lake is the origin of Cache Creek, which flows generally in a northeast about 8.5 miles to the confluence with its North Fork, through Capay Valley, south to the irrigation dam at Capay, north past the town of Yolo, and east and south into the Cache Creek settling basin before finally flowing into the Yolo Bypass.

Vegetation in upper Cache Creek consists mainly of deciduous trees and brush such as blue oaks and chapparal while the middle elevations are mostly riparian forest and valley oaks. The lower elevations are generally irrigated crops, orchards, or vineyards.

The topography of the basin varies from steep, rugged hill slopes of the Coast Ranges to the gentle slopes of the valley floor near Capay, located on the western edge of a large alluvial plain. The elevation ranges from 6,120 feet at Goat Mountain on the northern basin perimeter to about sea level near Yolo.

The geology of the basin consists of the Franciscan formation which forms the core of much of the Coast Ranges. Rock out-crops of this formation can only be found in the upper part of Cache Creek Basin and consist of marine sedimentary and volcanic rock. To the east of Clear Lake and in the central portion of the basin, rocks are predominantly of massive sandstone with imbedded conglomerates and silty shales. Continental deposits in the lower portion of the basin consist of silt-clay, sand, and gravel, and occur as discreet units and heterogenous mixtures. The younger overlying alluvium is similar and generally not as coarse as the continental deposits. Underground aquifers underlie the valley portion of the basin downstream from Rumsey. The size and extent of these aquifers are not known. Intensive agriculture, and to a lesser degree the seasonal recreation industry, comprise the main economic features of the basin. State Highways 16, 20, 29, and 53 are the main traffic arteries.

Putah Creek Basin

The basin is roughly square in shape and drains about 710 square miles of mountainous area to flat land. It is bounded on the north by Cache Creek Basin, on the east and south by downstream segments of Putah Creek Basin, and on the west by the Russian and Napa River Basins. Putah Creek originates in the Upper Putah Creek Basin and flows south to Lake Berryessa exiting Monticello dam and continuing east through the irrigation dam of Lake Solano. Water is diverted south to the Solano Water District while Putah Creek continues
east to the south fork and eventually into the Yolo Bypass. See chart 2. Solano Water District reports that the diversion channel has a capacity of 960 cfs.

Vegetation in the basin varies: moderately heavy coniferous forests at the higher elevations, to a mixture of deciduous trees and brush at the intermittent elevations, and vineyards, orchards and field crops on the valley floor lands.

The upper Putah Creek Basin ranges in elevation from about 4,700 feet in the mountains northwest of Middletown to 900 feet at the gaging station.

The geology of the of lower basin consists mostly of alluvium while the middle and upper elevations consist of marine sedimentary rock similar to the Cache Creek Basin.

Willow Slough Basin

The majority of the basin is located in Yolo County with the western most boundary lying in Napa County. The basin drains approximately 198 square miles. See chart 3. It includes the drainage areas of Lamb Valley Slough, Cottonwood Slough, and Union School Slough. Dry Slough Basin includes the drainage areas of Chickahominy Slough and Dry Slough. Winters Canal transects the upper portions of Willow and Dry Slough watersheds. Runoff from these sloughs located west of the canal flows under the canal by culvert. Smaller basin runoff west of the canal flows directly into the canal and is carried to the next slough or, occasionally, overtops the canal banks. Covell Drain includes the drainage of the North Davis Drain and a major portion of the City of Davis. Willow Slough, Dry Slough, and Covell Drain drain into the Willow Slough Bypass, which is a feature of the Sacramento River Flood Control Project. The East Davis watershed includes the area located just to the east of the Covell Drain and the City of Davis. This area drains directly into the Yolo Bypass.

Willow Slough is generally devoid of vegetation except in abandoned channels where large strands of continuous valley oaks exist. The dominant vegetation is field crops.

The western portion of the basin is characterized by steep slopes and extends into the Coast Range to elevations of

approximately 2,500 feet. The eastern portion of the watershed consists of slightly sloping elevations down to 65 feet.

The geology of the basin consists mainly of basin deposits which are alluvium in nature. There also exists some rhyolitic tuff and sedimentary rock in the middle of the basin.

Climate

Cache Creek Basin

The climate of the Cache Creek Basin is characterized by cool, wet winters and hot, dry summers. Temperatures range from slightly below freezing in winters to highs of over 100 degrees fahrenheit (F) at times during the summer. The climatological stations "Lakeport", "Clear Lake Highlands", and "Brooks Farnham Ranch" are representative of the Lower Creek watershed. The following table from reference 1 shows the average temperature and precipitation at those stations.

TABLE 1
CACHE CREEK BASIN CLIMATIC DATA

Station	Lakeport Elev. 1,347 ft.		Clearlake Highlands Elev. 1,365 ft.		Brooks Farnham Ranch Elev. 294 ft.	
Period of Record(yr)	27	71	9	18	45	51
Month	Ave. Temp. F	Ave. Precip. in.	Ave. Temp. F	Ave. Precip. in.	Ave. Temp. F	Ave. Precip. in.
Jan	41.2	6.18	41.8	5.85	44.8	4.06
Feb	46.7	4.90	45.0	4.46	48.5	4.10
Mar	53.7	3.36	48.1	2.13	52.9	2.63
Apr	52.4	2.03	51.5	1.84	58.2	1.31
May	61.7	0.88	60.2	0.50	65.3	0.60
Jun	69.8	0.45	67.3	0.19	72.4	0.20
Jul	75.0	0.04	73.5	0.01	78.4	0.01
Aug	74.8	0.05	73.3	0.17	75.8	0.02
Sep	65.3	0.24	66.5	0.37	72.1	0.19
Oct	56.7	1.74	57.5	1.29	63.4	0.96
Nov	47.2	2.88	48.6	3.35	52.6	1.75
Dec	38.4	5.87	41.4	4.61	46.0	4.17
Annual		28.52		24.77		20.00

Normal annual precipitation varies from a minimum of about 17 inches near the community of Yolo, and averages about 32 inches over the watershed. The major portion of the annual rainfall occurs during October through April period. Snowfall is very rare and has no

significant effect on the streamflow in the basin.

Putah Creek Basin

The climate of the Putah Creek Basin is also defined by cool wet winters and hot, dry summers. Temperatures in the basin are normally above freezing, but range from slightly below freezing in winter to highs of over 100 degrees F at times during the summer. There are no long term temperature records in the basin; however, records were available for Cloverdale 3 S.S.E., which is located approximately 20 miles west of Upper Putah Creek Basin and has similar climatic characteristics. The following table from reference 1 shows the average monthly temperatures recorded at that station.

TABLE II
PUTAH CREEK BASIN CLIMATIC DATA
Cloverdale 3 S.S.E.
Station Elev. 320 ft.
Period of Record(yr) 38

Month	Ave. Temp. F
Jan	47.2
Feb	50.5
Mar	54.1
Apr	58.3
May	63.5
Jun	69.4
Jul	72.9
Aug	71.7
Sep	70.3
Oct	63.3
Nov	55.5
Dec	49.9

The normal precipitation varies from a maximum of more than 80 inches along the western edge of the basin to a minimum of about 30 inches near the Guenoc gage, and averages about 49 inches over the basin. About 90 percent of the annual precipitation occurs during the October through April. Snowfall is rare and does not effect on flow in the basin.

Willow Slough Basin

The climate of Willow Slough Basin is one of cool wet winters and very hot, dry summers. Temperatures rarely reach below freezing in the winter while the summers can produce temperatures exceeding the century mark. Long-term temperature and precipitation records exist for two locations in or near the basin and are similar to the climatic characteristics of the basin. The Davis 1 WSW climate station is located on the eastern edge of the basin while the Winters station is just outside the southeastern boundary. Normal annual precipitation can range from about 18 inches in the east to 34 inches in the higher elevations. The following table presents precipitation and temperature data.

Table III
WILLOW SLOUGH BASIN CLIMATIC DATA

Station	Davis I WSW Elev. 60 ft.		Winters Elev. 130 ft.	
Period of Record(yr)	75	75	44	44
Month	Ave. Temp. F	Ave. Precip. in.	Ave. Temp. F	Ave. Precip. in.
Jan	44.7	3.30	45.5	4.71
Feb	49.6	3.10	51.1	3.57
Mar	53.2	2.28	54.7	2.81
Apr	58.1	1.24	60.6	1.24
May	64.6	0.39	67.4	0.35
Jun	71.1	0.13	74.2	0.13
Jul	74.7	0.01	78.1	0.02
Aug	73.3	0.03	76.6	0.05
Sep	70.3	0.01	73.2	0.31
Oct	62.9	0.26	65.1	0.99
Nov	52.6	0.89	54.0	2.82
Dec	45.5	2.08	46.3	3.73
Annual		16.74		20.81

Runoff

Cache Creek Basin

Streamflow and lake stage records were updated with the latest data available from the U.S. Geological Survey (USGS) and the California Department of Water Resources (DWR) for stream gages listed in the following table.

TABLE IV
CACHE CREEK BASIN STREAM GAGING STATIONS 1

Location	Drainage Area (sq. mi.)	Period of Record Used	Length of Record (Years)	Average Annual Runoff (acre-ft)	Station Operator
Clear Lake at Lakeport	528.0	1913-1984	72	5.00 2	USGS
Cache Creek near Lower Lake	528.0	1944-1991	47	256,000	USGS
North Fork Cache Creek at Hough Springs near Lower Lake	60.2	1971-1991	20	67,900	USGS
North Fork Cache Creek near Lower Lake 3	197.0	1930-1981	52	136,500	USGS
Bear Creek near Rumsey 3	100.0	1958-1980	23	35,760	DWR,CA
Cache Creek above Rumsey 3	955.0	1965-1986	19	541,200	DWR,CA
Cache Creek near Capay 3	1044.0	1942-1976	35	556,900	USGS
Cache Creek at Yolo	1139.0	1903-1991	89	378,900	USGS

1 Pertinent data for each stream gaging station were adapted to reflect the latest data available.
2 Average annual lake stage in feet above datum of gage, 1,318.65 feet.
3 Stream gage recorder discontinued.

Putah Creek Basin

Streamflow records are available for Putah Creek near Winters before and after regulation of Monticello Dam began in 1957. The following table presents the list of available records.

TABLE V
PUTAH CREEK BASIN STREAM GAGING STATIONS 1

Location	Drainage Area (sq mi)	Period of Record Used	Length of Record (Years)	Average Annual Runoff (acre-ft)	Station Operator
Putah Creek near Winters	574.0	1931-1956	26	345,600	USGS
Putah Creek Winters	574.0	1944-1991	47	256,000	USGS

1 Pertinent data for each stream gaging station were adapted to reflect the latest data available.

Willow Slough Basin

There is very little streamflow data available for this basin and for study purposes is considered an ungaged basin.

Flood Problems

All of flooding in the Cache Creek, Putah, and Willow Basins have resulted from general rainstorms. Local cloudburst storms have not produced any major recorded events.

Historical Flooding

Following are descriptive accounts of flooding and tables of peak flows and 3-day volumes where available.

Cache Creek Basin

Historically, there has been major flooding on Cache Creek. Below is a descriptive account of two events:

1940 - The north levee west of the Woodland-Knights Landing Bridge broke causing extensive flooding.

24 January, 1983 - Early in the morning the south levee of Cache Creek failed about 2 miles east of Woodland, north of Interstate 5. Following the break, 12 flood fighters were stranded for a few hours hours between the break site and the stub end of the levee system before being rescued by a California Highway Patrol helicopter. About 600 acres of agricultural land was flooded. Protective measures were performed to save the town of Yolo from being flooded.

Provided in the following table are historical flood observations for Cache Creek Basin.

TABLE VI
PEAK FLOW AND VOLUME DATA OF RECORD
CACHE CREEK BASIN

Location	Flood date	Peak Flow (cfs)	3-Day Volume (ac-ft)
Cache Creek near Lower Lake	24 Feb 58	8,000	30,550
	22 Dec 64	1	1
	5 Jan 65	5,320	23,720
	23 Jan 70	6,320	26,620
North Fork Cache Creek at Hough Springs near Lower Lake	26 Jan 83	3,980	19,400
	26 Jan 83	6,220	
North Fork Cache Creek near Lower Lake 2	24 Feb 58	13,500	31,860
	22 Dec 64	19,700	61,800
	5 Jan 65	15,700	40,060
	23 Jan 70	16,000	37,410
Bear Creek near Rumsey 2	22 Dec 64	6,820	10,680
	5 Jan 65	9,720	12,710
	23 Jan 70	5,900	10,400
Cache Creek above Rumsey	5 Jan 65	59,000 3	
	24 Jan 70	43,400 3	
Cache Creek at Rumsey	26 Jan 83	53,500	102,730
Cache Creek near Capay 2	24 Feb 58	51,600	98,980
	23 Dec 64	32,400	84,350
	5 Jan 65	44,500	96,620
	24 Jan 70	36,200	92,230
Cache Creek at Yolo	25 Feb 58	41,400	102,230
	23 Dec 64	26,200	79,360
	6 Jan 65	37,800	97,420
	24 Jan 70	34,600	125,720

1 Data is unavailable.
2 Station discontinued.
3 Value appears unreasonably high, possibly due to the extension of low flow rating table and slope-area measurements.

Putah Creek Basin

Flooding has not been a major problem on Putah Creek since Monticello Dam was built in 1957. Following is a description of the one major flooding event that produced the highest stage and peak flow to occur since regulation and a table of peak flow and volume data:

2 March 1983 - Farmer reports that the low bridge on Old Davis Road was inundated with at least one half foot of water, but was well within the confines of the surrounding levee system.

TABLE VII
PEAK FLOW AND VOLUME DATA OF RECORD
PUTAH CREEK AT WINTERS

Date	Peak Flow (cfs)	3-Day Volume (ac-ft)	
27 Feb 40	81000	226,000	
21 Jan 43	70300	124,365	
6 Feb 42	67200	136,266	
2 Mar 83	18700	100,956	1
24 Jan 70	16300	82,712	1
12 Apr 82	9930	53,316	1
30 Mar 74	7700	40,142	1
16 Mar 86	6700	37,488	1

1 Data reflects regulation of flow from Monticello Dam which began in 1957.

Willow Slough Basin

Flooding frequently occurs in the Cottonwood-Willow Slough watershed south of Cache Creek and in the Dry Slough/Davis watershed north of Putah Creek. See reference 2. The adjacent watersheds are part of the Yolo Creek system. Flows originating in the western part of the watershed often exceed the channel capacity of Willow Slough and their major tributaries, Chickahominy Slough and Lab Valley Slough, and cause flooding in the relatively flat agricultural lands in the eastern part of the county. Flooding is increased in the eastern side of the county when Sacramento River flows are diverted into the Yolo Bypass and Willow Slough gravity flow to the bypass is eliminated. Floodwaters pond behind the Yolo Bypass and Willow Slough Bypass levees until flood flows in the Yolo Bypass recede. No historical descriptive accounts are available on the ungaged basin.

Hydrologic Analysis

This section of the report presents a synopsis of the results of a review of the hydrologic analysis and hydrology shown in Sections "C" and "E" of reference 1 as it pertains to work required for this study on Cache Creek Basin.

Cache Creek

General

A major storm occurred in January 1983 and was centered over the ungaged area between Clear Lake Dam and Rumsey. Rainfall and streamflow data from this event were used in updating the computerized basin model (HEC-1) to verify the unit hydrograph, loss and routing parameters for the computer basin model used in this report.

Storm Analysis

The basin mean precipitation for the 1983 storm was estimated by using observed rainfall, and assigning weights to total rainfall amounts at pertinent precipitation gages. The time distribution for the January 1983 storm amounts are based on precipitation gages within the basin. Table C-3 of reference 1 lists the various stations used in the analysis. As mentioned in reference 1, the previous Cache Creek HEC-1 models were calibrated by reconstituting previous historical events. This was also done for the January 1983 event, which produced the greatest peak flows of record after regulation began. Rainfall and streamflow data of the historical event were used to calibrate the current HEC-1 model. Previously established procedures as indicated in reference 1 were used to compute the 100-year and Standard Project Storms centered over the ungaged area. See reference 1 for breakdown of subareas and isohyetal patterns used for this storm event.

Baseflow

The baseflow information remains the same as presented in the 1979 feasibility report.

Unit Hydrograph

The basic procedure used for developing unit hydrographs in this report is outlined in the Department of the Army's Technical Bulletin 5-550-3, "Flood Prediction Techniques," and in the Corps' Engineering Manual 1110-2-1405, "Flood Hydrograph Analyses and Computations." This procedure involves using the physical dimensions of the basin measured from topographic maps, an estimated average channel and basin hydraulic factor (Manning's "n") obtained by field observation, lag relationships, and summation curves (S-curves) obtained from unit hydrographs developed from reproduction of recorded floods. See

reference 3 for physical basin information and example unit hydrograp for subareas other than the Bear Creek Basin within the Cache Cre Basin that did not change. New unit hydrographs were computed for the Bear Creek Basin. The basin was divided into two subareas, one above the proposed detention basin site and one below. See table VIII for the data applicable to the computation of the new unit hydrographs for the Bear Creek Basin.

TABLE VIII
UNIT HYDROGRAPH INFORMATION
BEAR CREEK BASIN

Subarea	D.A. (sq. mi.)	L (mi)	Lca (mi)	S (ft/mi)	LLca/S1/2	n
Bear Creek Detention Basin Index Point 6	56.0	14.1	6.5	117.0	8.47	.06
Bear Creek near Rumsey Index Point 6B	44.0	17.0	8.0	158.8	10.47	.06

D.A. = Drainage area
L = Length of main channel
Lca = Length of channel opposite of centroid of basin
S = Slope of channel
n = Mannings' channel roughness coefficient

Loss Analysis

Uniform loss rates for the January 1983 flood ranged from 0.04 inches for the North Fork of Cache Creek to 0.20 inches in the lower portions of the Cache Creek Basin. These losses approximate those in reference 1. Therefore, there is no change in loss rates for the work required in this study.

Routing Parameters

The routing method used in the HEC-1 model for the Cache Creek Basin as mentioned in reference 1 was the Muskingham method. Muskingham coefficients used for Cache Creek below the Grigsby riffles are based on known channel characteristics and velocities observed during the January 1983 flood. These velocities ranging between 10 and 16 feet per second were much higher than previously observed. Adopted Muskingham parameters are representative of present channel conditions and are used in the current HEC-1 model. A routing diagram and a tabulation of adopted Muskingham coefficients are shown on chart 4 and include those of the divided Bear Creek basin. Computed peak flows and volumes generated by the HEC-1 models for the undivided and divided Bear Creek Basin were checked to ensure that the numbers did not change.

Flow Frequency

Flow records for Cache Creek at Capay remained unchanged since the gage was discontinued in 1984. Therefore, the peak and volume durati

frequency curves remain unchanged (reference 1). Sample statistics for an analytical peak flow frequency curve were not computed for the curve used from reference 1 because the data is regulated. However, sample statistics were needed to provide statistical data for a risk analysis as explained in the next paragraph. The regulated peak flow frequency was graphically drawn. Weibull plotting positions were used to plot the data, and a curve was drawn to fit the data points. The computed standard project peak flow generated by the Cache Creek HEC-1 model was compared to the frequency curve and found to have an exceedence frequency of about 500 years for Cache Creek at Capay. See chart 5 for the peak flow frequency curve at Capay.

Risk Analysis

Sample statistics as mentioned above for Cache Creek at Capay were needed for a risk analysis to be computed. These sample statistics were then used to define the uncertainty associated with the distribution of the data. See reference 7 for a more detailed explanation of a risk analysis. The statistics for the graphical curve were computed using the Flow Frequency Analysis software program developed by HEC. This program is based on Bulletin 17B WRC Guidelines (reference 4). The computed statistical parameters showed that the mean was 4.107, the standard deviation was 0.38, and the skew was -0.9. See chart 5 for the estimated 5 and 95 percent confidence limits.

Flood Hydrographs

The 100-, 200- and 500-year (standard project storm) storms were input into the Cache Creek HEC-1 model, and the flood hydrographs for Bear Creek Detention Basin and for Cache Creek at Capay were computed. See charts 7-9 for the 100-, 200-, and 500-year (SPF) flood hydrographs.

Putah Creek

Flood Analysis

In order for the data set of annual peak floods to be homogenous for Putah Creek at Winters, the storage level at Monticello Dam was assumed to be at or near capacity. This was assumed because the reservoir is operated for irrigation and not flood control. This could be considered a worst case analysis given the limitations of the data and was done in order to save expense and time in performing a coincident frequency analysis. A detailed study would consist of analyzing different Berryessa Lake storage levels when routing a 100-year event through the dam and evaluating resulting flows downstream. This detailed study is considered beyond the scope of a reconnaissance study. In order to simplify the analysis, it was also assumed that Putah Creek Diversion channel which has a capacity of 956 cfs, would not be in operation in order to simplify the analysis. Based on these assumptions, a homogenous data set for Putah Creek at Winters could be used for analyzing the annual peak flows that occurred on or after 1957 since operation of Monticello Dam began regulation in 1957. Using the total length of record of peak flows, would require converting the regulated data to natural data, which would be beyond the scope of this study.

Flow Frequency Analysis

The annual peak flows for Putah Creek at Winters were sorted in descending order and assigned Weibull plotting positions and plotted. A graphical curve was drawn to fit the data points. See chart 6. The peak flow associated with a 100-year event, based on the regulated peak flow frequency curve for Putah Creek at Winters, was 29,000 cfs. It was also assumed that between Putah Creek at Winters and Old Davis Road near Davis an additional 5 percent of the 100 year peak flow at Winters would be added due to local tributary runoff below Winters. This results in a peak flow of about 30,500 cfs at Old Davis Road. It should be noted that extreme caution should be exercised when using the peak flow frequency curve for Putah Creek at Winters since it was based on regulated data. As noted in the previous paragraph, the assumptions made, may be acceptable for reconnaissance purposes but a more in-depth analysis should be completed if Putah Creek Basin is studied in any capacity in the future.

Normal Depth Calculations

Field work was conducted to evaluate the January 1983 storm event that produced the highest stages and peak flows on lower Putah Creek since operation of Monticello dam in 1957. The stage at Old Davis Road on the south fork of Putah Creek was approximately 6 inches over the low water bridge. A previous HEC-2 study completed by Jones and Stokes on Putah Creek (reference 5) provided cross sections for locations including Old Davis Road. The peak flow for the January 1983 event for Putah Creek at Winters was 18,700 cfs. An additional 5 percent of the peak flow was added to account for local inflow below Winters, which produces 19,700 cfs. Cross sections were plotted at the Old Davis Road bridge and upstream of the bridge. The historic stage for the January 1983 event was plotted on both cross sections, and cross-sectional areas were computed and averaged. The flow, cross sectional area, and slope were used to calculate Manning's "n". The calculated "n" value of 0.05 was compared to a range of values from 0.03 to 0.07 for hydrologically similar streams from reference 6 and was found to be adequate. Using the calculated Manning's "n" and the 100-year peak flow of 30,500 cfs, the normal depth was calculated. The depth was then compared to the original cross sections, and it was found that there was considerable levee height and flow capacity available. Thus, it would appear that lower Putah Creek has at least 100-year channel capacity and the City of Davis would not be flooded if an event of this exceedence frequency occurred.

Willow Slough Basin

HEC-1 Model

As requested, a cursory review was made of the HEC-1 model of Willow Slough Basin developed by the A/E, Borcalli and Associates. The design storm, unit hydrographs, losses, routings, subbasin, and techniques were evaluated and appeared to be reasonable. Limited data prevented a true model calibration, but the A/E was able to validate parts of the model by field inspection of the streams in the basin

during a 1993 storm event. It was also requested that Hydrology Section determine where the 10-year/800 cfs and 100-year/1800 cfs Federal interest criteria were met. See Table IX, Table X, and Chart 3 for the various locations where there criteria were met.

TABLE IX
WILLOW SLOUGH BASIN
10-YEAR 800/CFS LIMITS

STREAMS	800 cfs LIMIT
Willow Slough	Below Lamb Valley Slough
Cottonwood Slough	Below Winters Canal
Union School Slough	Below Road 96
Dry Slough	Below Chickahominy Slough

TABLE X
WILLOW SLOUGH BASIN
100-YEAR /1800 CFS LIMITS

STREAMS	1800 cfs LIMIT
Willow Slough	Below Lamb Valley Slough
Cottonwood Slough	Below Winters Canal
Union School Slough	Approximately 1 mile upstream of Road 95
Dry Slough	Approximately 1 mile downstream Highway 505

References

1. U.S. Army Corps of Engineers, Sacramento District, "Cache Creek Basin, California, Hydrology Review Report", March 1985.

2. Borcalli and Associates, Sacramento, California, "Covell Drainage System Comprehensive Drainage Plan WMP-92-01-3," Draft October 1992.

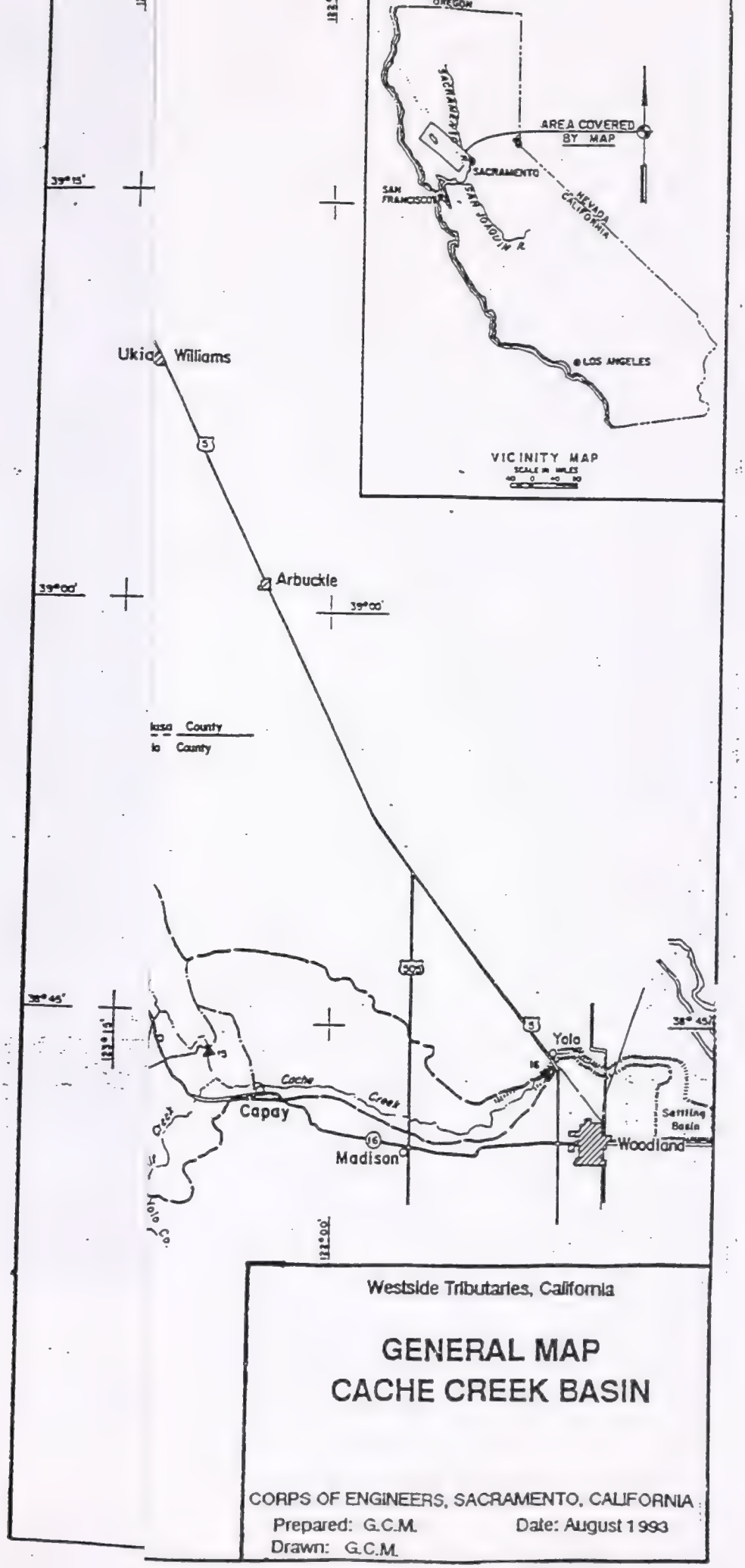
3. U.S. Army Corps of Engineers, Sacramento District, "Cache Creek Basin, California, Feasibility Report and Environmental Statement for Water Resource Development", February 1992.

4. Interagency Advisory Committee on Water Data, "Guidelines for Determining Flood Flow Frequency Analysis Bulletin 17B", revised 1981.

5. Jones and Stokes Associates, Sacramento, California, "Hydrologic Vegetation and Fisheries Analysis for the U.S. Fish and Wildlife Service Putah Creek Resource Management Plan", Draft April 1992.

6. Chow, Ven Te, "Handbook of Applied Hydrology", Mcgraw Hill, New York, 1964 p7-25.

7. U.S. Army Corps of Engineers, Washington D.C. , "Risk Analysis Framework for Evaluation of Hydrology/Hydraulics and Economics in Flood Damage Reduction Studies-EC 1105-2-XXXX, 1110-2-XXXX", July 1992.



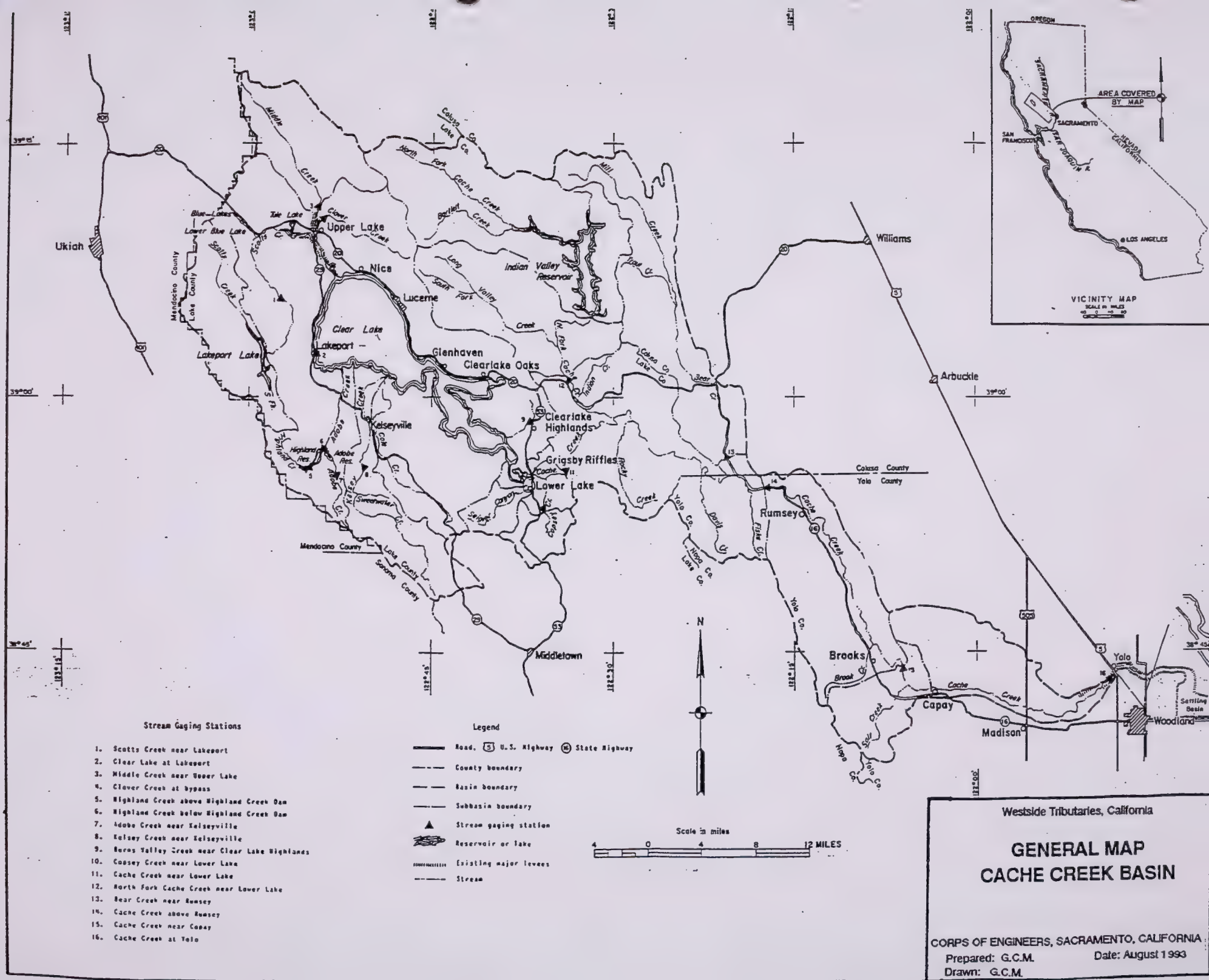
Westside Tributaries, California

GENERAL MAP
CACHE CREEK BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: G.C.M. Date: August 1993

Drawn: G.C.M.

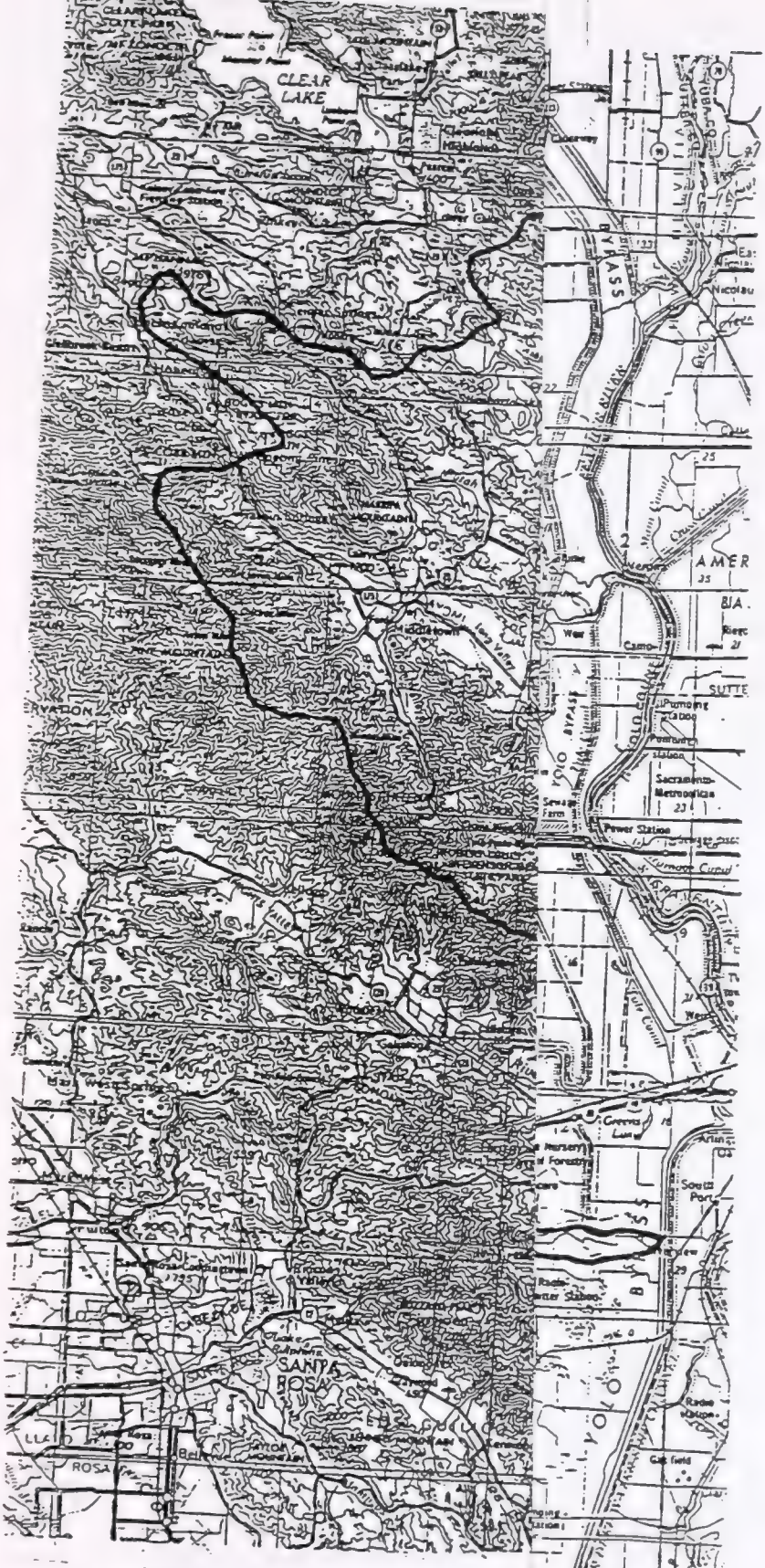


Westside Tributaries, California

GENERAL MAP
CACHE CREEK BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.C.M. Date: August 1993
Drawn: G.C.M.

CHART 1



Westside Tributaries, California

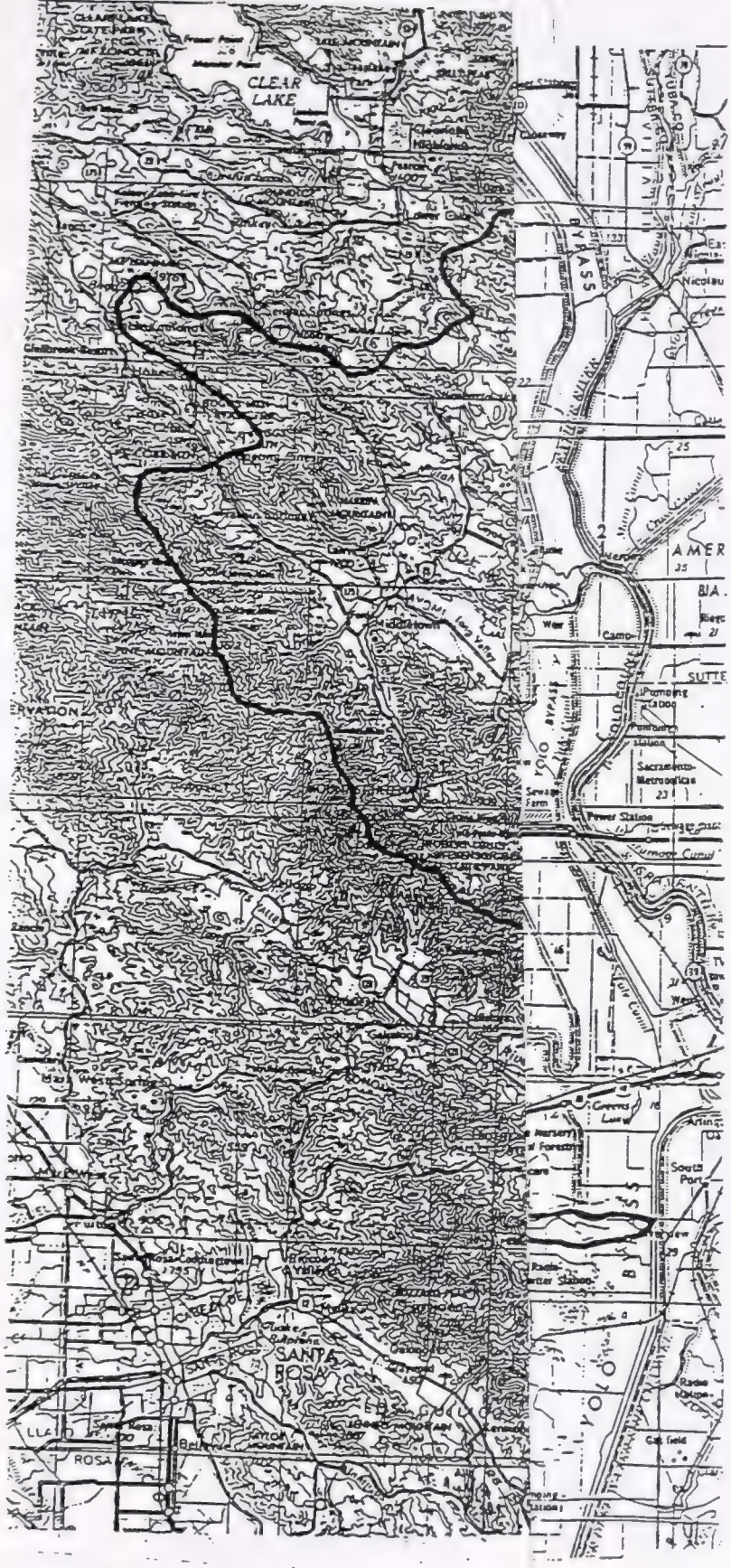
GENERAL MAP
PUTAH CREEK BASIN

LEGEND

Principal Watersh

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.C.M. Date: August 1993
Drawn: G.C.M.

CHART 2



Westside Tributaries, California

GENERAL MAP
PUTAH CREEK BASIN

LEGEND

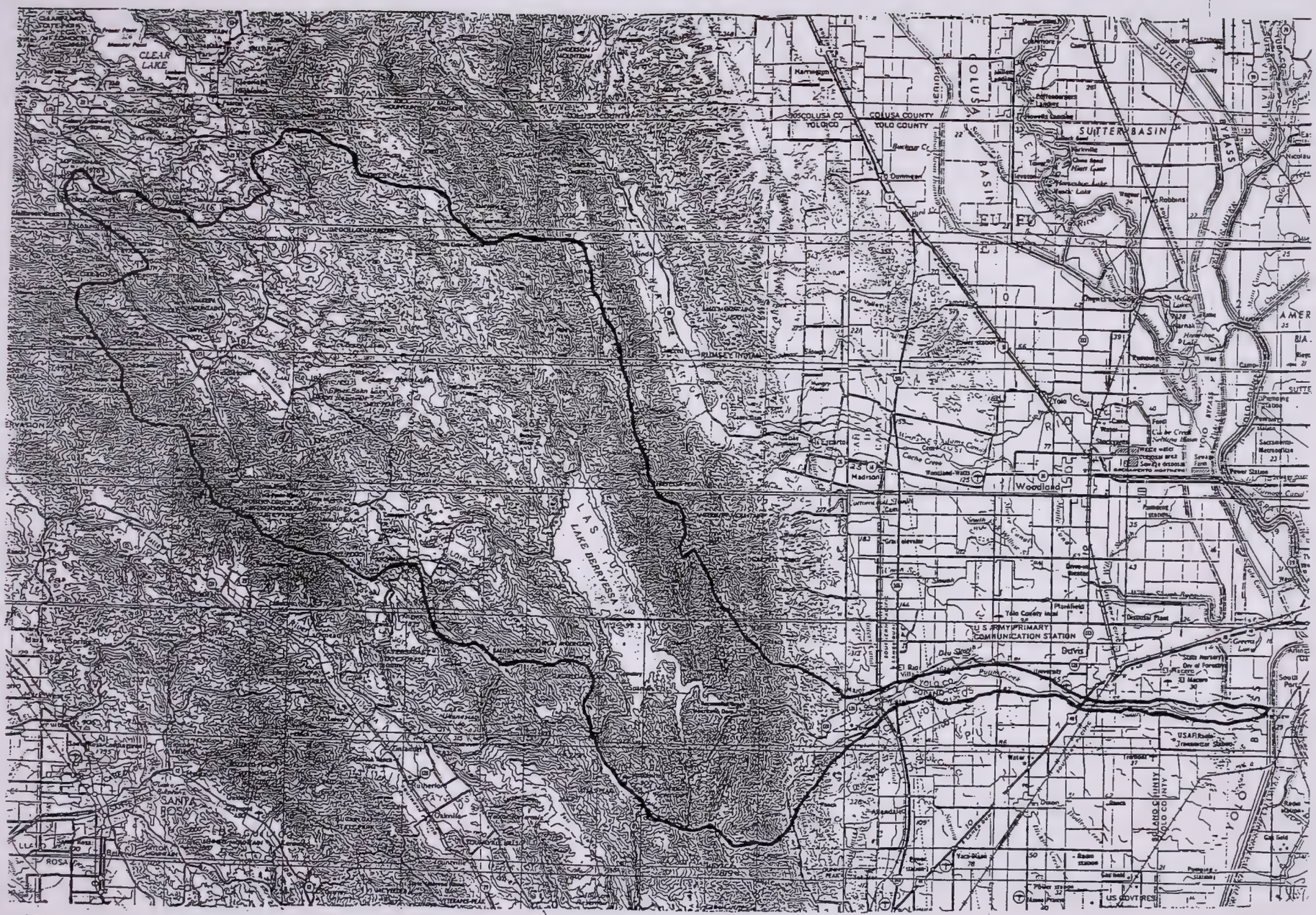
Principal Watersh

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: G.C.M. Date: August 1993

Drawn: G.C.M.

CHART 2



Westside Tributaries, California

GENERAL MAP
PUTAH CREEK BASIN

LEGEND

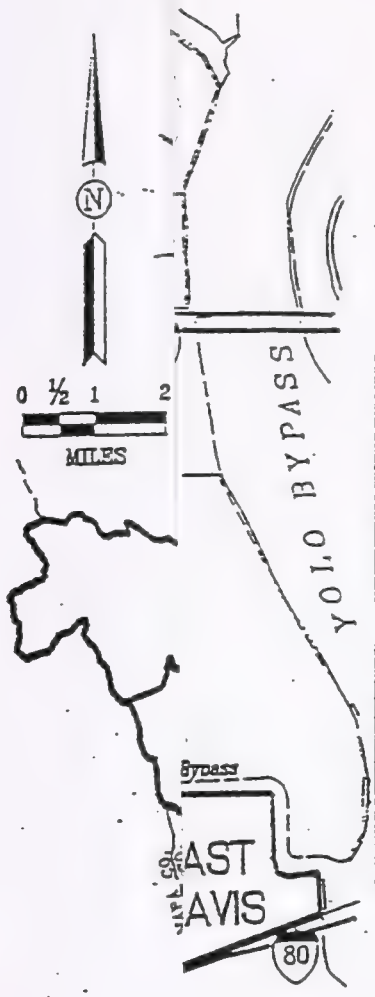
Principal Watershed Boundary

No Scale

N

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.C.M. Date: August 1993
Drawn: G.C.M.

CHART 2



10-YEAR 1800 CFS LIMITS

STREAM	INDEX NUMBER	FLOW (CFS)
WILLOW SLOUGH	1	900
COTTONWOOD SLOUGH	2	1300
WILLOW SLOUGH	3	2100
WILLOW SLOUGH	4	2350
UNION SCHOOL SLOUGH	5	850
DRY SLOUGH	6	1400
WILLOW SLOUGH	7	4000
WILLOW SLOUGH BYPASS	8	4000

100-YEAR 1800 CFS LIMITS

STREAM	INDEX NUMBER	FLOW (CFS)
WILLOW SLOUGH	1	3000
COTTONWOOD SLOUGH	2	4200
WILLOW SLOUGH	3	6100
WILLOW SLOUGH	4	7200
UNION SCHOOL SLOUGH	5	2000
DRY SLOUGH	6	2600
WILLOW SLOUGH	7	10600
WILLOW SLOUGH BYPASS	8	10600

LEGEND

Principal Watershed Boundary

Principal Drainage Course

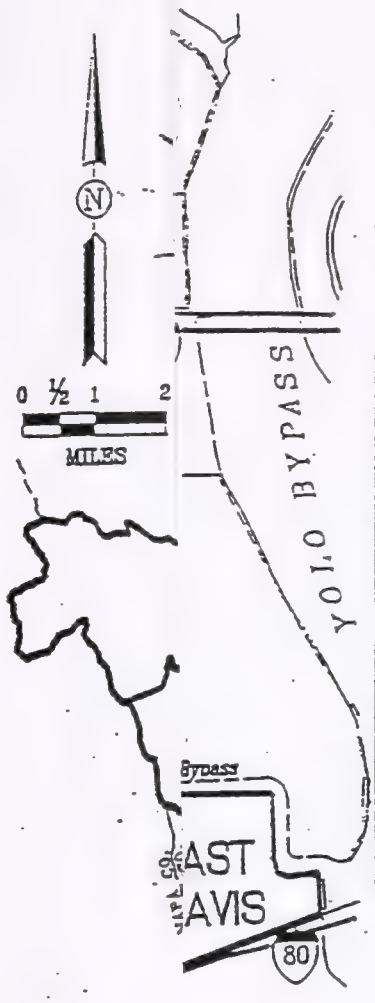
Index Number

Westside Tributaries, California

GENERAL MAP
WILLOW SLOUGH BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.C.M. Date: August 1993
Drawn: G.C.M.

CHART 3



10-YEAR 1800 CFS LIMITS

STREAM	INDEX NUMBER	FLOW (CFS)
WILLOW SLOUGH	1	900
COTTONWOOD SLOUGH	2	1300
WILLOW SLOUGH	3	2100
WILLOW SLOUGH	4	2350
UNION SCHOOL SLOUGH	5	850
DRY SLOUGH	6	1400
WILLOW SLOUGH	7	4000
WILLOW SLOUGH BYPASS	8	4000

100-YEAR 1800 CFS LIMITS

STREAM	INDEX NUMBER	FLOW (CFS)
WILLOW SLOUGH	1	3000
COTTONWOOD SLOUGH	2	4200
WILLOW SLOUGH	3	6100
WILLOW SLOUGH	4	7200
UNION SCHOOL SLOUGH	5	2000
DRY SLOUGH	6	2600
WILLOW SLOUGH	7	10600
WILLOW SLOUGH BYPASS	8	10600

LEGEND

Principal Watershed Boundary

Principal Drainage Course

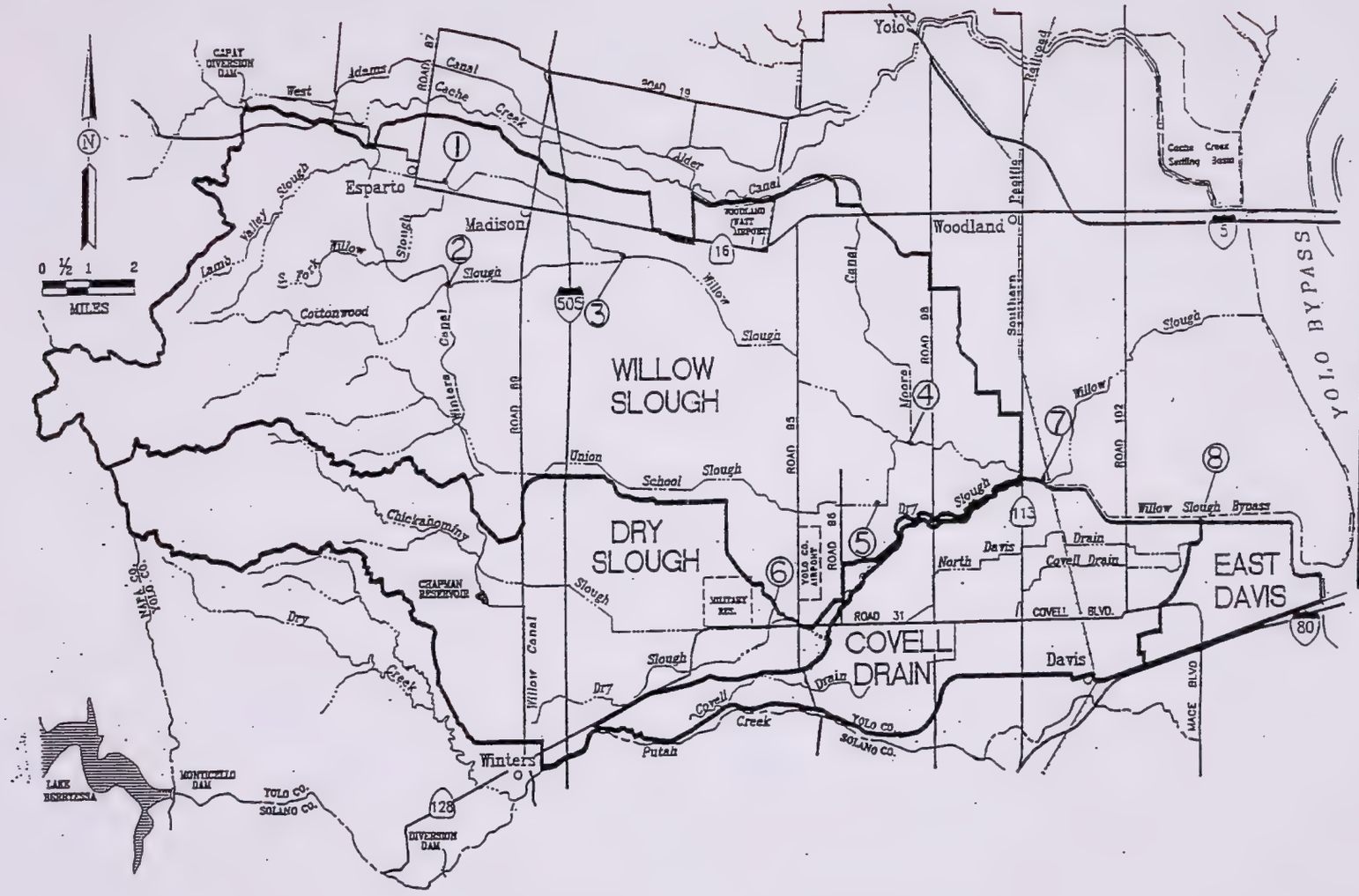
Index Number

Westside Tributaries, California

GENERAL MAP
WILLOW SLOUGH BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.C.M. Date: August 1993
Drawn: G.C.M.

CHART 3



10-YEAR 1900 CFS LIMITS

STREAM	INDEX NUMBER	FLOW (CFS)
WILLOW SLOUGH	1	900
COTTONWOOD SLOUGH	2	1300
WILLOW SLOUGH	3	2100
WILLOW SLOUGH	4	2350
UNION SCHOOL SLOUGH	5	850
DRY SLOUGH	6	1400
WILLOW SLOUGH	7	4000
WILLOW SLOUGH BYPASS	8	4000

100-YEAR 1900 CFS LIMITS

STREAM	INDEX NUMBER	FLOW (CFS)
WILLOW SLOUGH	1	3900
COTTONWOOD SLOUGH	2	4200
WILLOW SLOUGH	3	6100
WILLOW SLOUGH	4	7200
UNION SCHOOL SLOUGH	5	2000
DRY SLOUGH	6	3600
WILLOW SLOUGH	7	10600
WILLOW SLOUGH BYPASS	8	10600

LEGEND

Principal Watershed Boundary

Principal Drainage Course

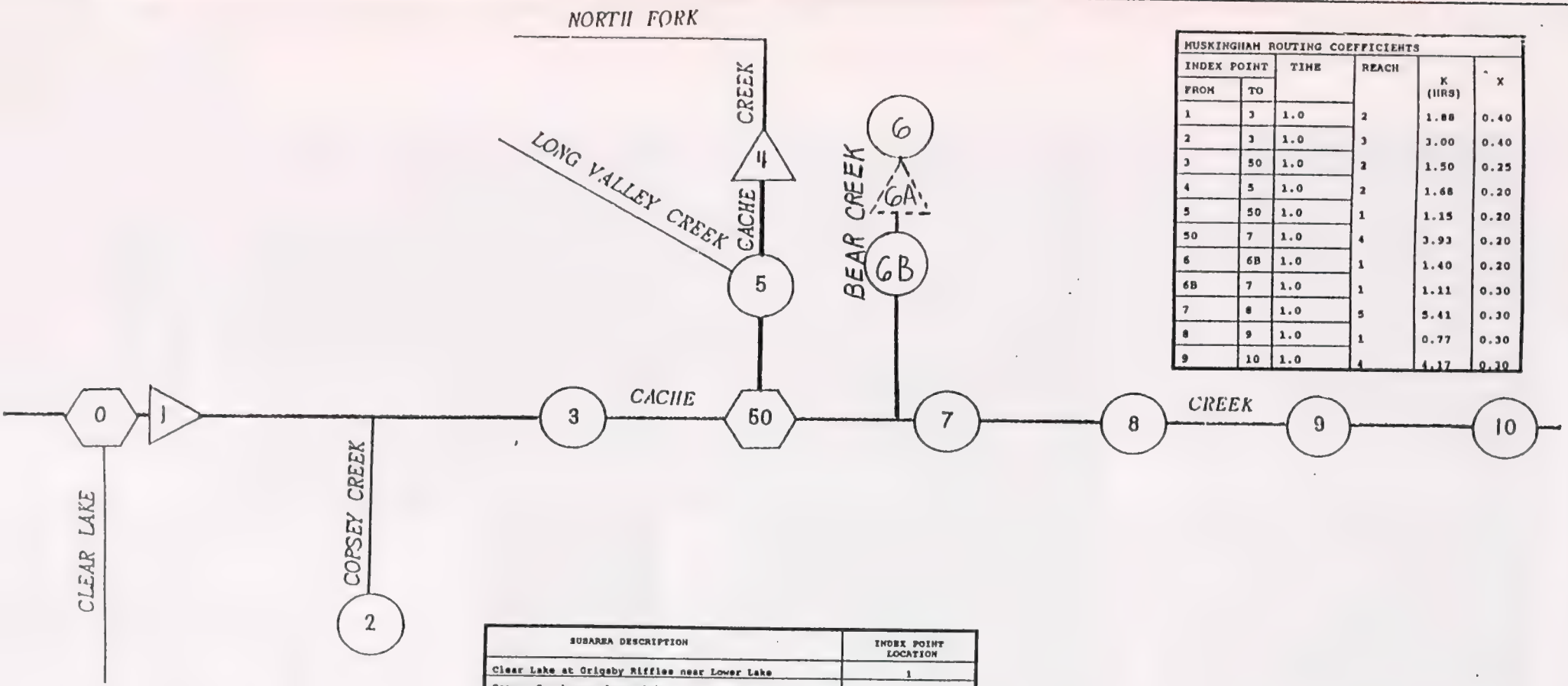
Index Number

Westside Tributaries, California

GENERAL MAP
WILLOW SLOUGH BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.C.M. Date: August 1993
Drawn: G.C.M.

CHART 3



MUSKINGHAM ROUTING COEFFICIENTS					
INDEX POINT		TIME	REACH	K (HRS)	X
FROM	TO				
1	3	1.0	2	1.88	0.40
2	3	1.0	3	3.00	0.40
3	50	1.0	2	1.50	0.25
4	5	1.0	2	1.68	0.20
5	50	1.0	1	1.15	0.20
50	7	1.0	4	3.93	0.20
6	6B	1.0	1	1.40	0.20
6B	7	1.0	1	1.11	0.30
7	8	1.0	5	5.41	0.30
8	9	1.0	1	0.77	0.30
9	10	1.0	4	4.17	0.30

SUBAREA DESCRIPTION	INDEX POINT LOCATION
Clear Lake at Grigsby Riffles near Lower Lake	1
Copsey Creek near Lower Lake	2
Cache Creek local between index 4, and 1, 2, and 3	
Cache Creek near Lower Lake	3
North Fork Cache Creek at Indian Valley Reservoir	4
North Fork Cache Creek local between 4 and 3	
North Fork Cache Creek near Lower Lake	5
Cache Creek at junction with North Fork	50
Bear Creek near Proposed Detention Basin	6
Bear Creek near Rumsey	6B
Cache Creek local between index 6 and 5, 4, and 3	
Cache Creek above Rumsey	7
Cache Creek local between index 7 and 6	
Cache Creek near Capay	8
Cache Creek local between index 8 and 7	9
Cache Creek local between index 9 and 8	
Cache Creek at Yolo	10

LEGEND:

Subarea — (2)

Reservoir — (1)

Routing Point — (hexagon)

Proposed Detention Basin — (dashed triangle)

Westside Tributaries, California

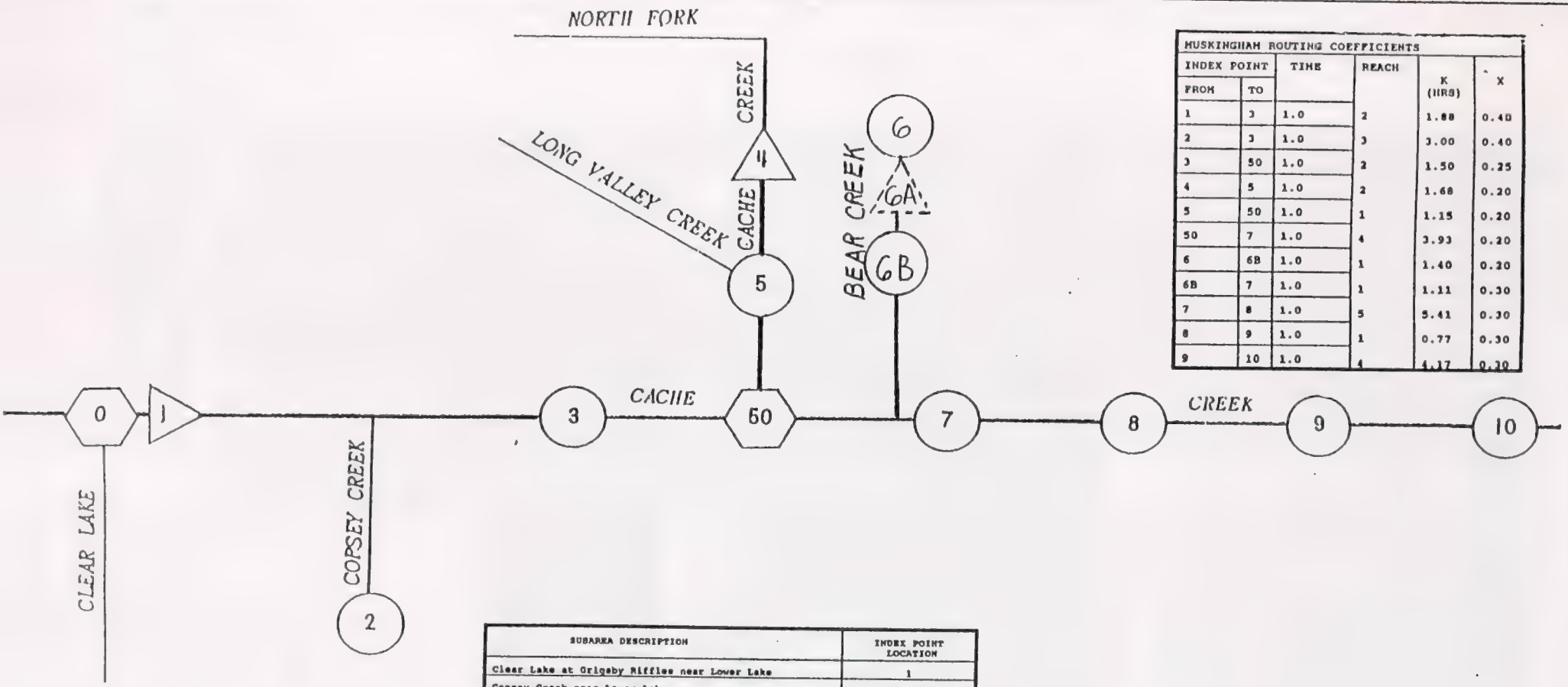
ROUTING DIAGRAM
CACHE CREEK BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: G.C.M.
Drawn: G.C.M.

Date: August 1993

CHART 4



MUSKINGHAM ROUTING COEFFICIENTS					
INDEX POINT		TIME	REACH	K (HRS)	X
FROM	TO				
1	3	1.0	2	1.88	0.40
2	3	1.0	3	3.00	0.40
3	50	1.0	2	1.50	0.25
4	5	1.0	2	1.68	0.20
5	50	1.0	1	1.15	0.20
50	7	1.0	4	3.93	0.20
6	6B	1.0	1	1.40	0.20
6B	7	1.0	1	1.11	0.30
7	8	1.0	5	5.41	0.30
8	9	1.0	1	0.77	0.30
9	10	1.0	4	4.17	0.30

SUBAREA DESCRIPTION	INDEX POINT LOCATION
Clear Lake at Grigsby Riffles near Lower Lake	1
Copsey Creek near Lower Lake	2
Cache Creek local between index 4, and 1, 2, and 3	
Cache Creek near Lower Lake	3
North Fork Cache Creek at Indian Valley Reservoir	4
North Fork Cache Creek local between 4 and 3	
North Fork Cache Creek near Lower Lake	5
Cache Creek at junction with North Fork	50
Bear Creek near Proposed Detention Basin	6
Bear Creek near Rumsey	6B
Cache Creek local between index 6 and 5, 4, and 3	
Cache Creek above Rumsey	7
Cache Creek local between index 7 and 6	
Cache Creek near Capay	8
Cache Creek local between index 8 and 7	9
Cache Creek local between index 9 and 8	
Cache Creek at Yolo	10

LEGEND:

Subarea — (2)

Reservoir — (1)

Routing Point — (hexagon)

Proposed Detention Basin — (dashed triangle)

Westside Tributaries, California

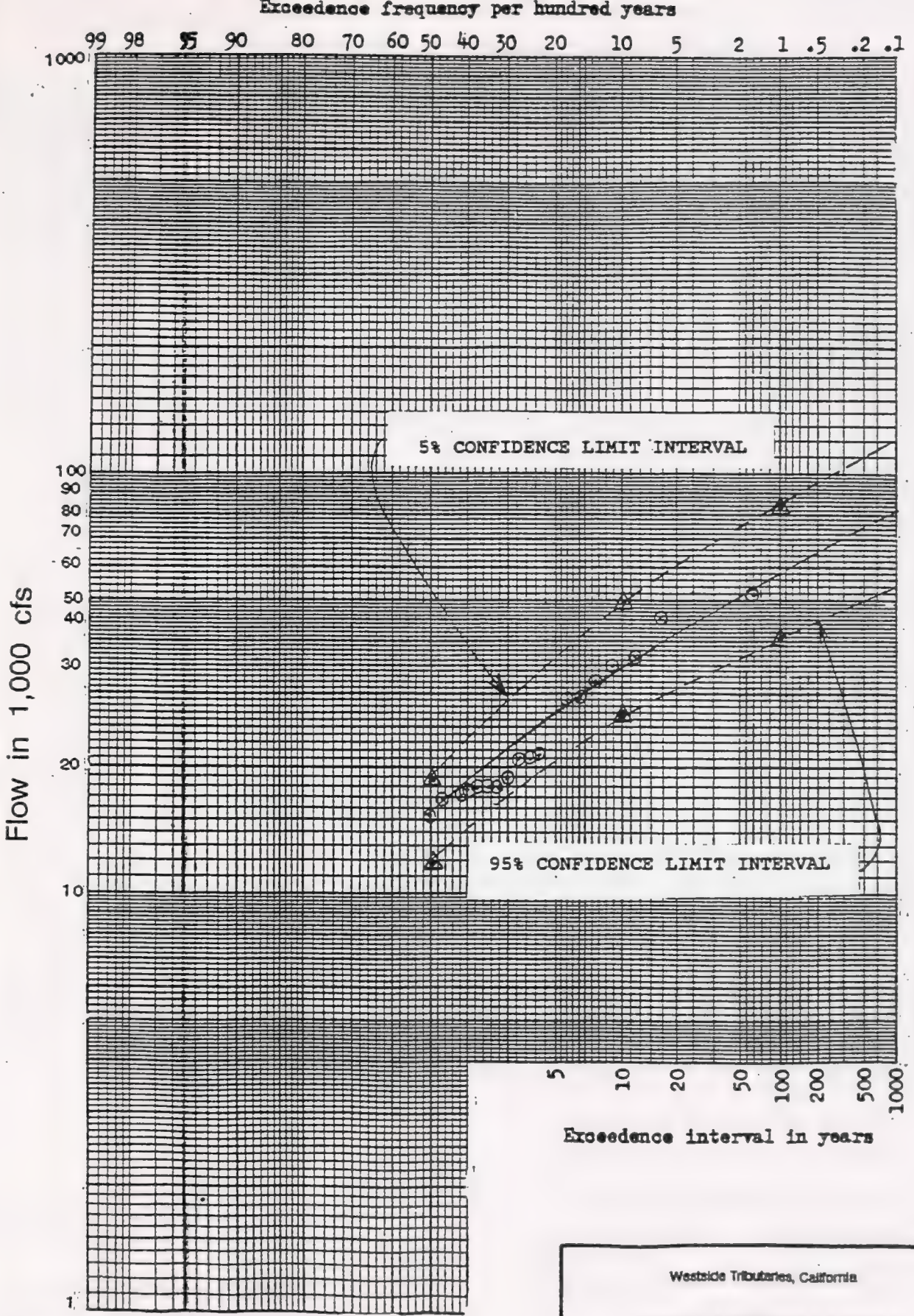
ROUTING DIAGRAM
CACHE CREEK BASIN

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: G.C.M.
Drawn: G.C.M.

Date: August 1993

CHART 4



Notes:

1. Statistics were not computed due to regulation at Indian Valley Reservoir and Clear Lake.
2. Period of record 1943-1984.
3. Total contributary drainage area is 1019 square miles.

Westside Tributaries, California

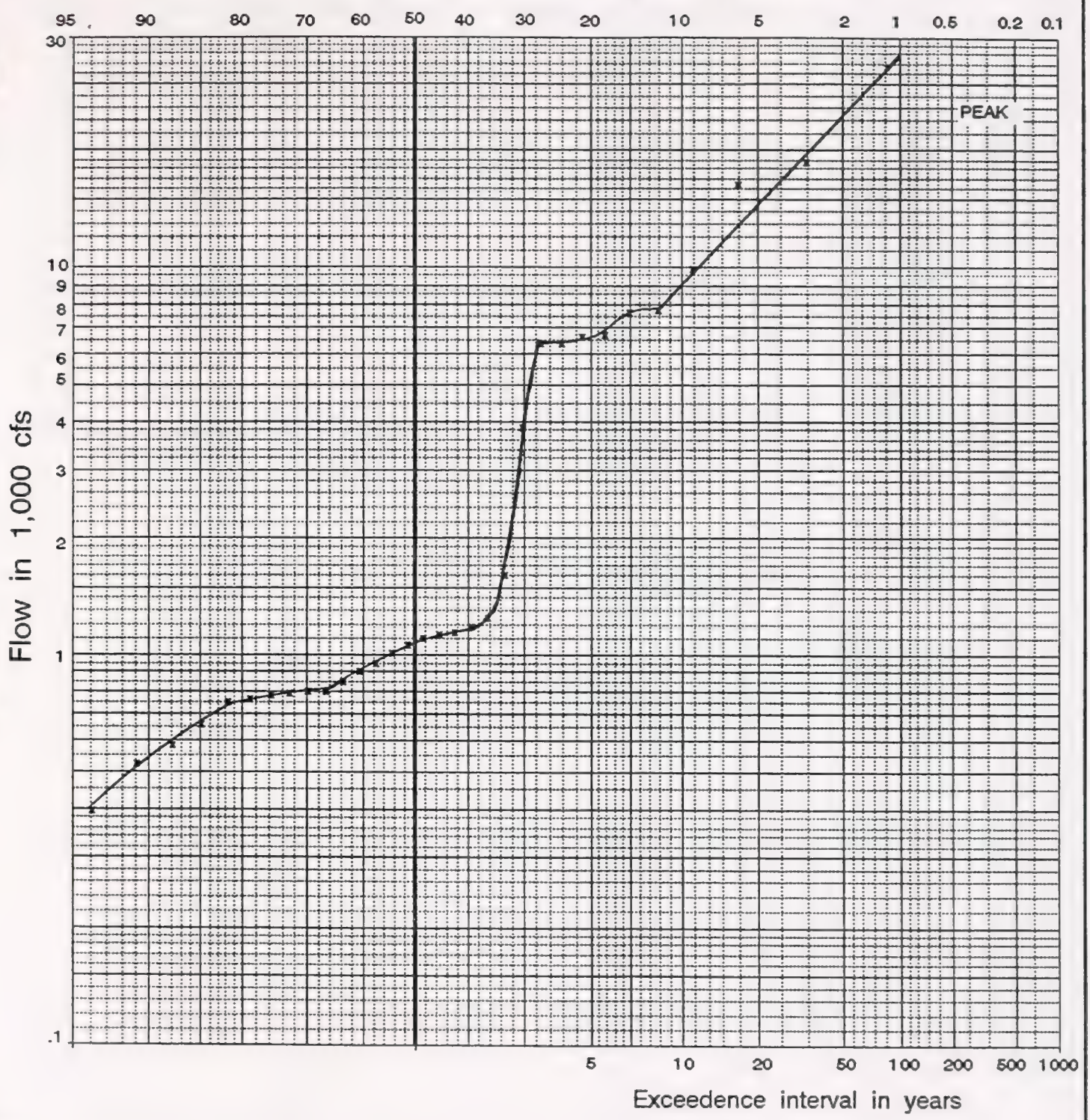
CACHE CREEK AT CAPAY PEAK FLOW FREQUENCY CURVE

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: G.C.M. Date: August 1983

Drawn: G.C.M.

CHART 5



Notes:

1. This curve was drawn graphically from recorded data.
2. This curve was graphically extended to the 100 year event.
3. Plotting positions were determined by using Weibull formula P=m/(n+1) ,were n=number of years of record and m=rank number. The plotting positions "P" were based on 32 years of record (1957-88).
4. No statistics were calculated due to regulation of flows.

WESTSIDE TRIBUTARIES, CALIFORNIA

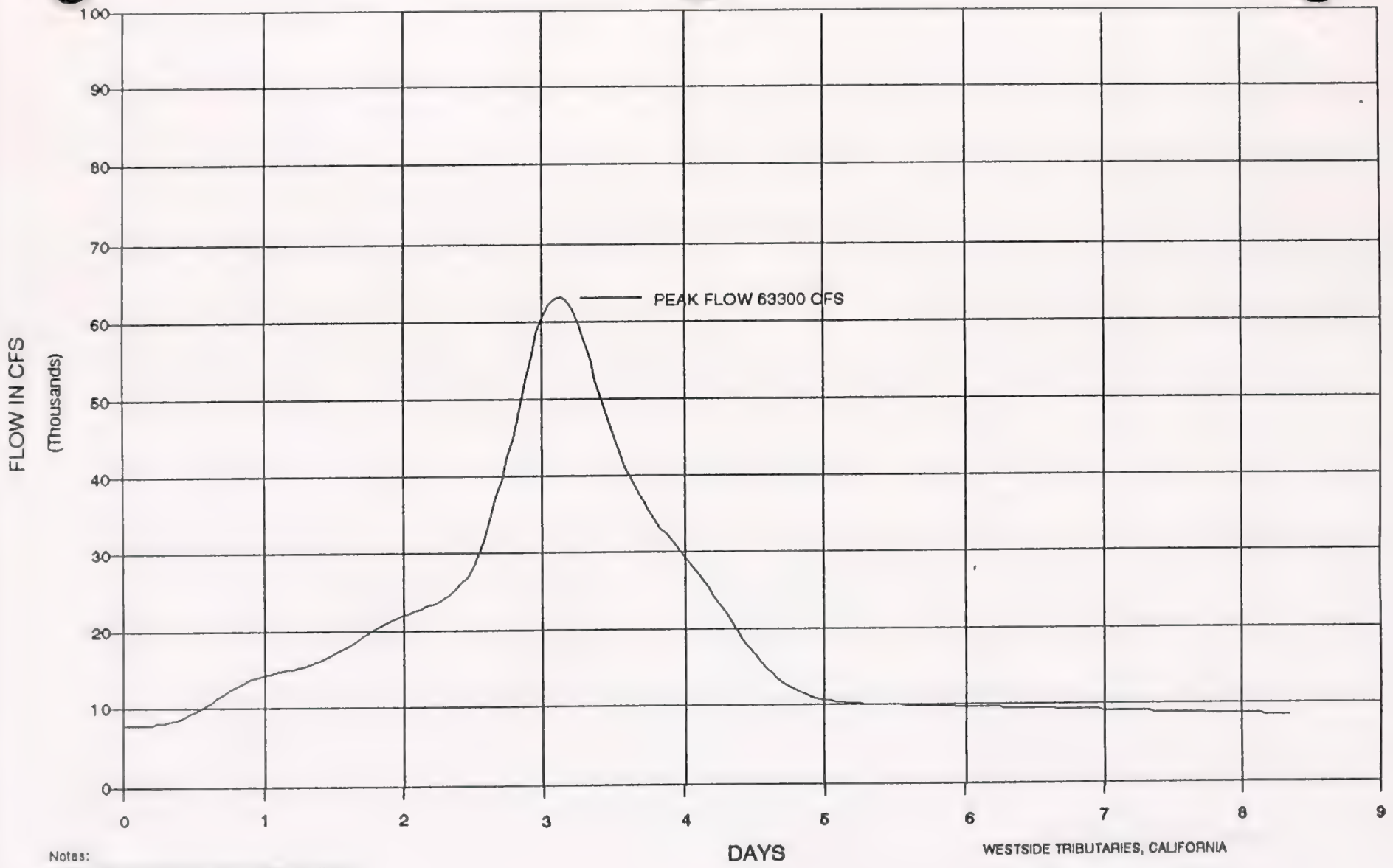
PUTAH CREEK AT WINTERS PEAK FLOW FREQUENCY CURVE

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA

Prepared: G.C.M. Date: Jul 1993

Drawn: G.C.M. File : PUTQPK.WQ1

CHART 6



Notes:

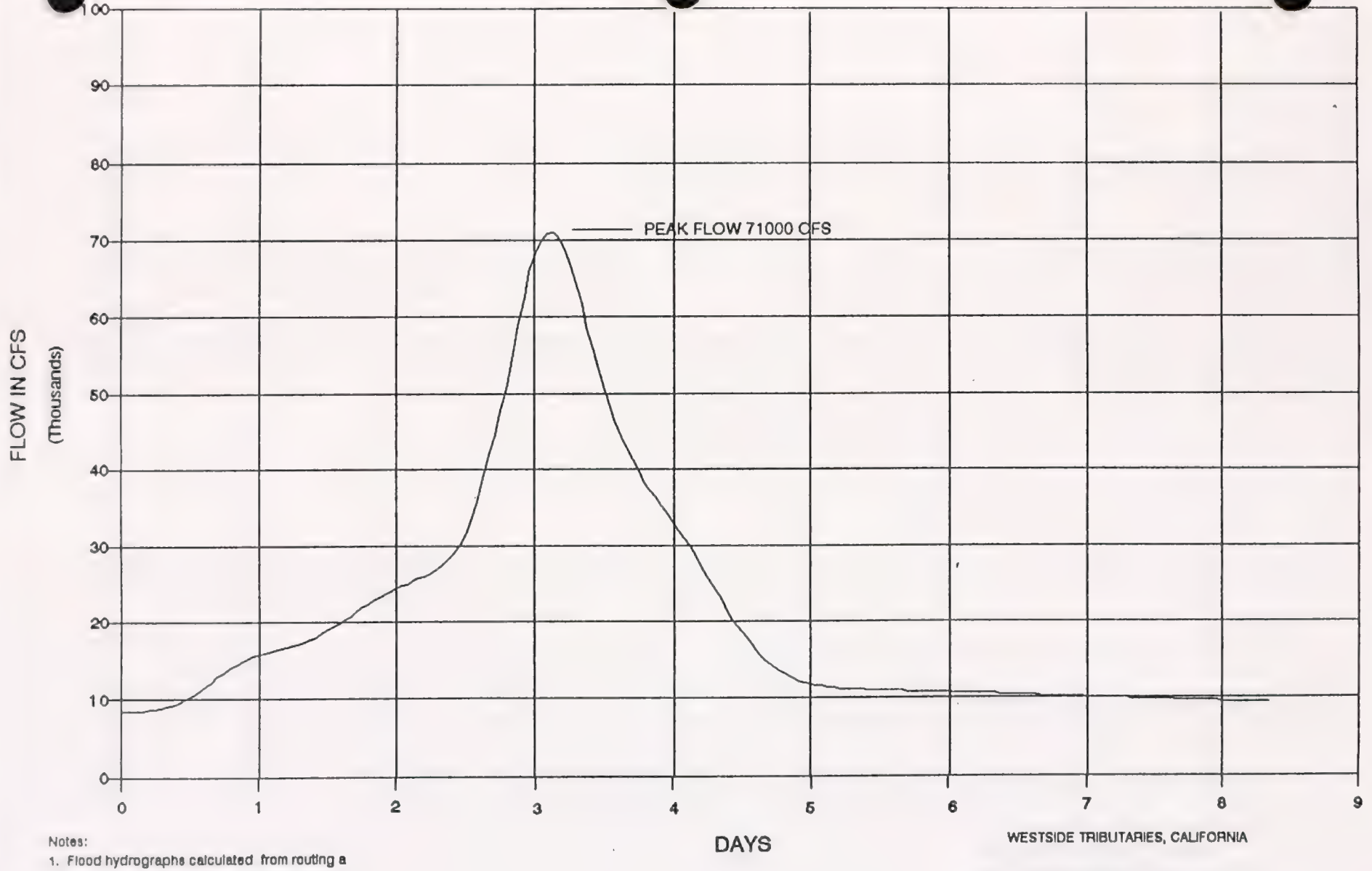
1. Flood hydrographs calculated from routing a hypothetical 500 year storm event through a calibrated HEC-1 rainfall runoff model.

WESTSIDE TRIBUTARIES, CALIFORNIA

CACHE CREEK AT CAPAY
100 YEAR FLOOD HYDROGRAPH
INDEX. 10:

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.C.M. Date: 20 JUNE 1993
Drawn: G.C.M. File : CAPAYHY.WQ1

CHART 7



Notes:

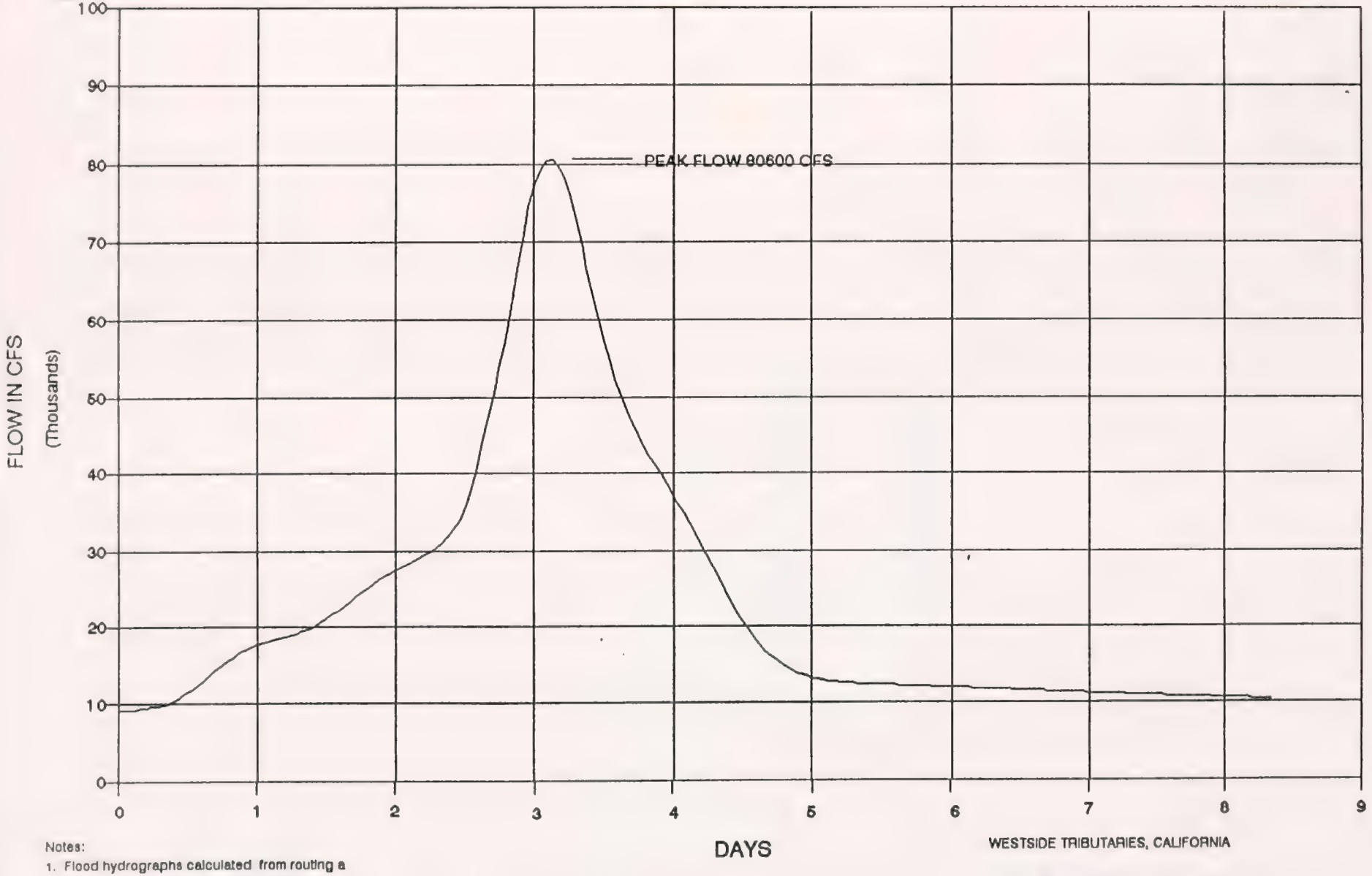
1. Flood hydrographs calculated from routing a hypothetical 500 year storm event through a calibrated HEC-1 rainfall runoff model.

WESTSIDE TRIBUTARIES, CALIFORNIA

CACHE CREEK AT CAPAY
200 YEAR FLOOD HYDROGRAPH
INDEX. 10:

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.C.M. Date: 20 JUNE 1993
Drawn: G.C.M. File : CAPAYHY.WQ1

CHART 8



Notes:

1. Flood hydrographs calculated from routing a hypothetical 500 year storm event through a calibrated HEC-1 rainfall runoff model.

WESTSIDE TRIBUTARIES, CALIFORNIA

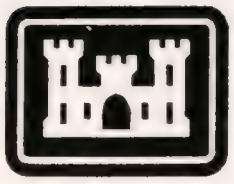
CACHE CREEK AT CAPAY
500 YEAR FLOOD HYDROGRAPH
INDEX. 10:

CORPS OF ENGINEERS, SACRAMENTO, CALIFORNIA
Prepared: G.C.M. Date: 20 JUNE 1993
Drawn: G.C.M. File : CAPAYHY.WQ1

CHART 9

APPENDIX C

BASIS OF DESIGN



DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

BASIS OF DESIGN AND COST ESTIMATES (RECONNAISSANCE LEVEL)

BORCALLI & ASSOCIATES, INC.
CONSULTING ENGINEERS
4620 Northgate Blvd., Suite 120
Sacramento, California 95834
Tel: (916) 564–3300

MARCH 1994

TABLE OF CONTENTS

		PAGE
SECTION 1 -- INTRODUCTION		1
1.01	Purpose and Scope	1
1.02	Study Participants	1
SECTION 2 -- STUDY AREA DESCRIPTION		2
2.01	Putah Creek	2
2.02	Willow Slough Bypass	3
2.03	Cache Creek	4
SECTION 3 -- FLOOD PROBLEMS/INITIAL EVALUATIONS		10
3.01	Putah Creek	10
3.02	Willow Slough Bypass	10
3.03	Cache Creek	12
SECTION 4 -- PLAN FORMULATION		14
4.01	Planning Objective	14
4.02	Design Considerations and Criteria	14
	1. Design Flows	14
	2. Water Surface Profiles	15
	3. Cross Sections	15
	4. Energy Losses	16
	5. Uncertainty Allowance	17
	6. Slope Protection	18
	7. Channel Configuration	18
	8. Levee Configuration	18
4.03	Development of Alternative Plans	19
	1. Planning Assumption	19
	2. Technical Studies of Existing Flood Conditions	20
	a. Determination of PFP, PNP, and Nondamaging Channel Capacities	20
	b. Floodplain Mapping	24
	c. Volumetric Considerations in Delineating Floodplains	27
	d. Land Subsidence Considerations	27

TABLE OF CONTENTS
(Continued)

		PAGE
	3. Description of Preliminary Alternative Plans	29
	4. Screening of Preliminary Plans	31
	a. Detention Storage	32
	b. Channel/Levee Improvements	34
4.04	Final Alternative Plans	39
	1. Plan Descriptions	39
	a. Alternative 1 -- Channel and Levee Improvements ..	39
	b. Alternative 2 -- Levee Improvements	43
	2. Project Features	47
	a. Lands and Damages	47
	b. Relocations	48
	c. Project Roads	49
	d. Channels and Canals	49
	e. Levees	50
	f. Project Impacts	52
	g. Operation and Maintenance	55
	h. Functional Operation	55
	i. Hazardous and Toxic Waste	55
	j. Care of Water	56
SECTION 5 -- COST ESTIMATES		57
5.01	Summary of Costs	57
5.02	Basis of Estimates	57
	1. First Cost	57
	2. Investment and Annual Costs	60
SECTION 6 -- BIBLIOGRAPHY		69

LIST OF TABLES

No.	Title	
1	Estimated PFP, PNP, and Nondamaging Channel Capacities ...	22
2	Estimated Cache Creek Peak Flows	26
3	Cache Creek Diversions for Floodplain Analysis	28

TABLE OF CONTENTS
(Continued)

		PAGE
4	Comparison of Peak Discharges of Cache Creek at Yolo With and Without Maximum Detention Storage on Bear Creek ...	33
5	Comparison of Peak Discharges of Cache Creek at Yolo With and Without 37,000 Acre-Feet Detention Storage at Wilson Valley	35
6	Off-Stream Detention Requirements Necessary to Eliminate Flooding on Cache Creek	36
7	Alternative 1 - Channel and Levee Improvements (100-Year) Summary of Project Features	41
8	Alternative 2 - Levee Improvements (100-Year) Summary of Project Features	45
9	Cost Estimate Summary	58
10	Alternative 1 - Cache Creek Channel and Levee Improvements Above Road 102 100-Year Flood Protection Cost Estimate	61
11	Alternative 1 - Cache Creek Channel and Levee Improvements Above Road 102 200-Year Flood Protection Cost Estimate	63
12	Alternative 2 -- Cache Creek Levee Improvements Above Road 102 100-Year Flood Protection Cost Estimate	65
13	Alternative 2 - Cache Creek Levee Improvements Above Road 102 200-Year Flood Protection Cost Estimate	67

LIST OF APPENDICES

A PLATES:

1 Location Map
2 Willow Slough Bypass Basin
3 Floodplains - Cache Creek (1 of 7)
4 Floodplains - Cache Creek (2 of 7)
5 Floodplains - Cache Creek (3 of 7)
6 Floodplains - Cache Creek (4 of 7)
7 Floodplains - Cache Creek (5 of 7)
8 Floodplains - Cache Creek (6 of 7)
9 Floodplains - Cache Creek (7 of 7)
10 Profile - Woodland Floodplain
11 Preliminary Alternatives

TABLE OF CONTENTS

LIST OF APPENDICES

A PLATES (Continued):

12 Cache Creek Alternative 1 (1 of 2)
13 Cache Creek Alternative 1 (2 of 2)
14 Cache Creek Alternative 2 (1 of 2)
15 Cache Creek Alternative 2 (2 of 2)
16 Typical Cross Section - Cut Section
17 Typical Cross Section - Embankment Section
18 Typical Levee Sections - New Levee Embankment
19 Typical Slope Protection - Setback Levee/Channelization
20 Cache Creek 100-Year Water Surface Profiles
Existing Conditions and Alternative 1 - Channel and Levee Improvements
21 Cache Creek 100-Year Water Surface Profiles
Existing Conditions and Alternative 2 - Levee Improvements

B COST ESTIMATES (BELOW ROAD 102)

C DETENTION STORAGE COSTS

D REAL ESTATE REPORT

SECTION 1 -- INTRODUCTION

1.01 Purpose and Scope

The purpose of this Basis of Design report is to present the reconnaissance-level evaluation of flood problems, as well as design criteria and costs for alternative structural flood control measures to reduce or alleviate flood problems along the Westside Tributaries to the Yolo Bypass. For purposes of this study, the Westside Tributaries include Putah Creek, the Willow Slough Bypass, and Cache Creek (see Plate 1). Reaches of interest include:

- Putah Creek from the City of Davis to the South Fork of Putah Creek
- Willow Slough Bypass and its two major tributaries -- Willow Slough and Dry Slough
- Cache Creek from the Capay Diversion Dam to the Cache Creek Settling Basin

This report was prepared as required by Contract DACW05-93-R-0028 with the Department of the Army, Sacramento District, U. S. Army Corps of Engineers (Corps of Engineers).

1.02 Study Participants

Borcalli & Associates, Inc. (B&A) under contract with the Sacramento District Corps of Engineers is conducting studies and preparing a Basis of Design report. B&A is interacting with other federal, state, and local agencies during this work effort. The potential nonfederal sponsor is Yolo County.

SECTION 2 -- STUDY AREA DESCRIPTION

2.01 Putah Creek

Putah Creek originates in the Coast Range and generally flows from west to east to the floor of the Yolo Basin where it disperses in the area of the Putah Sinks. The watershed is approximately 810 square miles and includes portions of Lake, Napa, and Yolo counties.

To alleviate frequent flooding in the vicinity of the present City of Davis, residents began in 1871 to divert Putah Creek into what is now the South Fork channel. The South Fork branches from the original channel, known as the North Fork, about 4,000 feet upstream of the Interstate 80 bridge.

The Corps of Engineers began the Putah Creek Project during World War II. Dams were placed at the entrance and terminus of the North Fork to establish the South Fork as the only functioning channel of Putah Creek. In the late 1940's the Corps of Engineers constructed levees along both sides of the creek extending from the junction of the North and South Forks to the Yolo Bypass.

The U. S. Bureau of Reclamation began planning for the Solano Project, a water supply project, in the mid-1940's. In 1957 Monticello Dam was completed on Putah Creek approximately seven miles west of Winters, in Napa County. The dam forms Lake Berryessa, which has a capacity of 1,600,000 acre-feet. Included in the Solano Project are the Solano Diversion Dam and Lake Solano, which has a capacity of 720 acre-feet, and the Putah South Canal, which conveys water from the diversion dam south to Solano County.

2.02 Willow Slough Bypass

The Willow Slough, Dry Slough, and Covell Drain watersheds drain approximately 190 square miles to the Willow Slough Bypass, which is a feature of the Sacramento River Flood Control Project (see Plate 2). The levees creating the Willow Slough Bypass, which drain into the Yolo Bypass, range from approximately 5 feet to 20 feet in height above the adjacent land.

The Willow Slough watershed includes the drainage areas of Lamb Valley Slough, Cottonwood Slough, and Union School Slough. The towns of Esparto and Madison are within the Willow Slough watershed. The western portion of the watershed is characterized by relatively steep slopes and extends into the Coast Range to elevations of approximately 2,500 feet. The eastern portion of the watershed is slightly sloping alluvial plains with elevations down to 65 feet.

The Dry Slough watershed includes the drainage area of Chickahominy Slough and Dry Slough. The watershed characteristics are similar to those of Willow Slough.

The Winters Canal is owned and operated by the Yolo County Flood Control & Water Conservation District. It ranges in elevation from approximately 210 to 160, and transects the upper portions of the Willow Slough and Dry Slough watersheds. In general, runoff from the principal sloughs west of the canal is discharged under the canal by means of a culvert or inverted siphon. Runoff from smaller subbasins located west of and adjacent to the Winters Canal enters the canal and is conveyed south to the next slough where it is discharged by means of a spillway or, in some cases, may overtop the canal banks.

The Covell Drain watershed includes the drainage area of the North Davis Drain, and a major portion of the City of Davis. Peak discharges in the Covell Drain do not meet the criteria for federal interest and as such was not included in this study.

The vast majority of the Willow Slough and Dry Slough watersheds are used for agricultural purposes with urban uses primarily limited to the immediate vicinity of the towns of Esparto and Madison. The upper watersheds are primarily covered with chaparral. Oak trees and grasses are present on the foothills. Cover on the lower portions range from dry land pasture to irrigated row crops and orchards.

2.03 Cache Creek

Cache Creek originates in the Coast Range and generally flows southeasterly to the Yolo Bypass. The watershed is approximately 1,150 square miles and includes portions of Colusa, Lake, and Yolo counties.

The Cache Creek Basin consists of two areas. These areas are known as the Clear Lake area, including the tributaries to Clear Lake, and the Cache Creek area, including Cache Creek and its tributaries.

The Clear Lake area encompasses approximately 528 square miles of the Cache Creek watershed. Water flows from Clear Lake through the Clear Lake Outlet Channel through the Clear Lake Dam into Cache Creek.

Below Clear Lake Dam, Cache Creek flows approximately 46 miles to the Capay Diversion Dam. Two major tributaries, the North Fork and Bear Creek, enter within this reach.

Indian Valley Dam and Reservoir was completed on the North Fork of Cache Creek in 1975. It has an active reservoir storage capacity of 260,000 acre-feet and is primarily operated for irrigation water supply and energy production.

Indian Valley Reservoir has a total storage capacity of 300,000 acre-feet, of which 40,000 acre-feet is for flood control storage. Clear Lake Dam is operated to control the level of the lake during nonflood periods, regulate summer irrigation releases, and generate hydroelectric power.

Below Capay Dam, Cache Creek flows easterly to its confluence with the Yolo Bypass. The Cache Creek Settling Basin is located at the mouth of the creek.

The Cache Creek Settling Basin was originally constructed by the Corps of Engineers in 1937 as part of the Sacramento River Flood Control Project. The purpose of the Settling Basin is to preserve the floodway capacity of the Yolo Bypass by entrapping sediment carried by Cache Creek. The Settling Basin was modified for a design flow of 30,000 cfs in 1992 to add 50 years of sediment storage capacity. Primary modifications included raising the existing east, south, and north levees, relocating the west levee, constructing a training channel and levee, and raising and lengthening the main overflow weir. Improvements did not extend upstream beyond Road 102.

In the late 1950's the Corps of Engineers enlarged and extended the levees along both banks of Cache Creek. The primary work extended from slightly above Interstate 5 to the Settling Basin. The design flow for the work was 30,000 cfs, a recurrence interval of approximately ten years.

On April 17, 1958, the Yolo County Board of Supervisors requested that only a minimum amount of work be performed on the Cache Creek levees to preserve the benefits from the Wilson Valley Reservoir Project. At that time the State of California and Yolo County were contemplating constructing the Wilson Valley Reservoir on the main stem of Cache Creek to a capacity of 1,000,000 acre-feet, reserving space for flood control.

The Wilson Valley Reservoir Project has not been constructed.

Cache Creek has a widened stream channel between Capay Bridge and the Interstate 505 crossing. The resulting reduced velocities cause deposition of bedload. The depositions result in meandering and bank cutting.

Between Interstate 505 and the Moore Canal Crossing, Cache Creek is relatively straight with deposition occurring during high flows. The deposited material is finer than the previous reach and causes some meandering.

The reach extending from the Moore Canal Crossing to Stevens Bridge (Road 94B) is primarily exposed clayey deposits of the Tehama Formation. Deposition and meandering do not occur through this reach.

The bed has minimal movement from Stevens Bridge (Road 94B) to the leveed section near Yolo.

The report entitled "Draft Program Environmental Impact Report, Cache Creek Aggregate Resources Mining Activities and Policy Alternatives," prepared by Dames & Moore, May 30, 1991, provides an overview of past sediment transport studies on Cache Creek. Portions of that overview follow:

"Most of the sediment moving through the study reach originates upstream of Capay Dam. As discussed in Section 3.2.1, the primary source of sediments to Cache Creek is Pliocene-Pleistocene age nonmarine strata which crop out in the drainage basin (WET, 1989). The clay and silt of these strata are easily eroded and transported by Cache Creek. Rocks of the Great Valley Sequence also comprise an important source of sediment to Cache Creek. These rocks are particularly prone to erosion where it is highly deformed, such as the confluence of Cache Creek and Bear Creek (WET, 1989). Chert gravels found in Cache Creek below Rumsey are remnants of the Franciscan Formation, suggesting transport of sediments of this formation from the upper reaches of the Basin.

A sediment transport study of Cache Creek by Lustig & Busch (1967) showed that, at Rumsey, eight percent of the total suspended sediment is from the Bear Creek Drainage Basin, 21 percent is from North Fork Cache Creek (prior to Indian Valley Reservoir) and the remaining 71 percent is from Cache Creek proper. The proportion of sediment generated by North Fork Cache Creek has been reduced since Indian Valley Reservoir became operational. Sediment yield increases by 32 percent between Rumsey and Capay, primarily as the result of hillslope failure on the east side of Capay Valley (WET, 1989). While North Fork Cache Creek, Bear Creek, and Cache Creek above Rumsey generate suspended sediment at the rates of 602, 451, and 593 tons per square mile per year, respectively, the rate between Rumsey and Capay is 2,702 tons per square mile per year (WET, 1989). Sediments are also trapped upstream of the study area by Capay Dam (WET, 1989). The sediment transport at Yolo has been estimated to be 40 percent less than at Capay (Lustig & Busch,

1967). Neglecting aggregate mining, average sediment deposition in the study area has been estimated at 73,900 cubic yards (approximately 122,000 tons) in a normal year, and up to 292,000 cubic yards during a 100-year flood (Simons, Li and Associates, Inc. 1986)."

The geomorphic study prepared by Simons, Li & Associates, Inc. in 1987, found that the channel patterns have changed in the reaches influenced by gravel mining. It was found that:

> "The mining operations have disturbed the channel banks and overbanks to a degree where a large supply of coarse sediment is available to the stream during flood flows. The availability of coarse sediment in these reaches appears to have caused the channel to shift to a more braided-type pattern typical of a bed-load channel."

In Phase III of the Sacramento River Flood Control System Evaluation, the reaches between Yolo and Road 102 were found to have degraded and scoured over time. However, geotechnical analysis found the levees to have slope stability factors of 3.0 and greater.

Cache Creek between Capay Bridge and Yolo provides high quality aggregate material, which has been mined since the early 1900's. The aggregate has been used within Yolo and Solano counties for construction material.

There has been extensive controversy over the environmental impacts of the aggregate mining activities. The Yolo County Board of Supervisors adopted interim in-channel regulations in 1979 to regulate aggregate mining along Cache Creek. Yolo County is in the process of working out a program to bring resolution to this

controversy and provide for the long-term management of the resources of Cache Creek.

The geotechnical staff of the Corps of Engineers have provided a technical review of the work by Roger Foott Associates, Inc. (see "Geotechnical Assessment of Levees in the Mid-Valley Area, Sacramento River Flood Control System Evaluation," dated December 21, 1989). Preliminary review of maintenance records and field observations did not indicate that significant levee embankment problems exist along Cache Creek. Analysis of levee raising and its impact on the stability of the existing levees revealed that existing slope stability factors are 3.0 and greater. Levees will remain stable under additional fill.

SECTION 3 -- FLOOD PROBLEMS/INITIAL EVALUATIONS

3.01 Putah Creek

Draft results of Phase IV of the Corps of Engineers Sacramento River Flood Control System Evaluation has identified deficient design levee elevations along portions of Putah Creek. The deficiencies exist for a total of 1.99 miles of the left bank and 3.53 miles of the right bank. It is suspected that land subsidence due to groundwater pumping in the vicinity of Davis may be the primary reason for the deficiencies.

Flooding has not been a major problem along Putah Creek since the construction of Monticello Dam in 1957. An analysis of stream gage stage versus discharge records indicates (at least at the gage location) there is sufficient capacity to convey the 100-year flow (see "Hydrology of the Westside Tributaries of the Yolo Bypass, California," dated August 1993). Therefore, flood control alternatives will not be developed for Putah Creek.

3.02 Willow Slough Bypass

In Phase IV of the System Evaluation, the Willow Slough Bypass was estimated to provide less than a 20-year level of flood protection. Draft results of Phase IV of the System Evaluation has identified deficient design levee elevations along the Willow Slough Bypass. The deficiencies extended from Mile 3.44 to Mile 6.16 on the left bank, and Mile 3.45 to Mile 3.93 for the right bank. The deficiencies are thought to be a result of land subsidence due to groundwater extraction.

Flood insurance studies have been conducted by the Federal Emergency Management Agency (FEMA) for areas in and around the Willow Slough Bypass. A description of the historic flooding for

the project area and areas tributary to the project area is provided in FEMA's Flood Insurance Study (revised 1988) for Yolo County. This description follows:

> "During the past 40 years, flooding has occurred in the Yolo County study area in 1937-38, 1940, 1943, 1950, 1955, 1958, 1963, 1967, 1973, 1975, and 1986 (References 4 through 8). Flooding generally occurs in the relatively flat agricultural lands within the eastern two-thirds of the county.
>
> Flooding frequently occurs in the Cottonwood-Willow Slough watershed south of Cache Creek and in the Dry Slough/Davis watershed north of Putah Creek. The adjacent watersheds are part of the Yolo Creek System. Flows originating in the western part of the watersheds exceed the channel capacity of Dry and Willow Sloughs and their major tributaries, Chickahominy Slough and Lamb Valley Slough, and cause flooding in the relatively flat agricultural lands in the eastern part of the county. Flooding is increased at the eastern side of the county when Sacramento River flows are diverted into the Yolo Bypass and gravity flow to the bypass is eliminated. Severe flooding occurred along the Sacramento River and Yolo Bypass in February 1986. Floodwaters pond behind the Yolo Bypass and Willow Slough Bypass levees until flood flows in the bypasses recede."

Flooding frequently occurs in the Cottonwood-Willow Slough watershed south of Cache Creek and in the Dry Slough/Davis watershed north of Putah Creek (see "Covell Drainage System Comprehensive Drainage Plan WMP-92-01-3," dated October 1992). Because of the sparse development in the watershed, however, structural flood control measures cannot be economically justified.

Therefore, structural flood control alternatives will not be developed for the Willow Slough Basin. However, nonstructural and environmental restoration measures will be addressed in the overall study effort by others.

3.03 Cache Creek

The Cache Creek levee system is only designed to convey a peak flow rate of 30,000 cfs (approximately the 10-year event). The 100-year peak flow rate is about 64,000 cfs below Capay Dam.

In January 1983, a flow of about 33,000 cfs resulted in the failure of an upstream section of the training channel levee of the Cache Creek Settling Basin. A hole was punched into the north levee to relieve pressure on the deteriorating levees. During this event, emergency crews also sandbagged the levee crown in the vicinity of Yolo to prevent overtopping.

Draft results of the Phase IV System Evaluation has identified deficient design levee elevations along portions of Cache Creek. The design water surface plus three feet of uncertainty allowance exceeds the left and right levee crowns from approximately Mile 5 to Mile 10. It is suspected that land subsidence due to the extraction of groundwater is the primary cause. Geotechnical investigations found no foundation problems with the levees.

The 50-, 100-, and 500-year floodplains were developed for Cache Creek below Capay Dam as part of this study. The flood elevations and floodplains are shown on the Plates 3 through 9 in Appendix A, and are summarized below. The development of these flood elevations and limits of inundation will be discussed in Section 4 of this report.

Between Capay Dam and Road 94B flood flows up to and including the 500-year discharge are generally contained within the width of the meandering floodway (normally 400 to 1,500 feet wide). All flows remain adjacent to Cache Creek and no overland diversions occur.

Below Road 94B, Cache Creek overtops its banks and several separate floodplains develop as floodwaters leave the Creek and travel overland leaving the Cache Creek floodway proper. Flooding in these overbank areas is generally shallow (two feet or less for the 500-year event) and very expansive -- often over a mile in width.

A significant portion of the town of Yolo and the City of Woodland is within the 50-, 100-, and 500-year floodplain. The threat of future flooding to these areas is significant due to the low level of protection afforded by the Cache Creek system. Therefore, structural flood control alternatives will be developed to alleviate flooding along Cache Creek between the Capay Diversion Dam and the Cache Creek Settling Basin.

SECTION 4 -- PLAN FORMULATION

4.01 Planning Objective

The planning objective for this plan formulation process is to develop and evaluate structural alternatives to reduce or alleviate flooding along Cache Creek between the Capay Diversion Dam and the Cache Creek Settling Basin for the 100- and 200-year flood events.

As discussed in Section 3, Flood Problems/Initial Evaluations, preliminary analyses revealed that structural flood protection on Putah Creek and the Willow Slough Basin (including Willow and Dry Sloughs) was not economically practical. Therefore, the plan formulation and evaluation process which follows will only focus on Cache Creek.

4.02 Design Considerations and Criteria

1. Design Flows

The 1991 4.01E version of the HEC-1 computer program "Watershed Modeling Computer Program" was used to compute peak discharges and runoff volumes. The HEC-1 model presented in the report entitled, "Hydrology of the Westside Tributaries of the Yolo Bypass, CA, Reconnaissance Study," prepared by the Corps of Engineers, November 1993, served as the base model for this study.

The base HEC-1 model was revised using the modified Puls Routing Method below Capay Dam to reflect cross section information obtained for this study. Based upon the results of the HEC-2 model reflecting the channel capacity of Cache Creek, the model was further modified to reflect the loss of overflow from the Cache Creek system. Several additional

routing reaches were added and the model was extended to the Settling Basin. The modified model was used to develop the flows used in the floodplain mapping.

The alternative project features were designed to safely pass the 100- and 200-year peak discharges. These discharges were obtained by modifying the Corps of Engineers' HEC-1 models to alleviate overflows from leaving the Cache Creek system or to reflect detention storage. The design flow for conveyance facilities was 64,000 cfs and 71,900 cfs for the 100- and 200-year flood events, respectively.

2. Water Surface Profiles

The 1991 4.6.2 version of the HEC-2 computer program "Water Surface Profile" was used to compute the project design water surface profiles by the Standard Step Method. HEC-2 models were developed to simulate existing and project conditions.

Insufficient data exists to calibrate the HEC-2 model. The reasonableness of the model results were confirmed by comparing computed water surface elevations for a discharge of 33,000 cfs with conditions observed during the 1983 flood.

3. Cross Sections

Cross sections used in the HEC-2 model for the project were compiled from three different sources. For the reach extending from Capay Diversion Dam to the vicinity of Road 85, cross sections were field-surveyed by Andregg Inc., as part of this project work. For the reach between Road 85 and 1.5 miles upstream of Interstate 5, cross sections were developed from topographic information contained in a report entitled, "Spring 1993 - Annual In-Channel Mining Report," dated

April 1993. For the reach beginning 1.5 miles upstream of Interstate 5 to 600 feet downstream of Road 102, cross sections were field-surveyed by Andregg, Inc., as part of this project work. From 600 feet downstream of Road 102 to the end of the Cache Creek Settling Basin, cross section were taken from the Corps of Engineers' "Design Memorandum No. 1, Cache Creek Settling Basin, Final General Design Memorandum," dated January 1987.

Where existing cross-sectional information was inadequate in width to contain the flow, sections were extended using topographic information from 7.5 Minute Quadrangle Maps. Bridge information was obtained from available construction drawings.

4. Energy Losses

Mannings "n" values were estimated for the existing conditions following the procedures contained in the "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains," United States Geological Survey Water-Supply Paper 2339. Mannings "n" values varied for each cross section depending upon the degree of channel/overbank irregularity and cross-sectional variation, effects of obstructions, and the amount of vegetation. Overbank "n" values ranged from 0.03 to 0.06. Channel "n" values generally ranged from 0.035 to 0.056. For flow areas where flood waters leave the natural channel and flow overland, an "n" value of 0.07 was used for urban areas and 0.04 for rural (nondeveloped) areas.

Two types of transition losses were included in the HEC-2 model. Contraction and expansion loss coefficients for gradual transitions were taken as 0.1 and 0.3, respectively.

For losses between bridge cross sections, contraction and expansion loss coefficients of 0.3 and 0.5, respectively, were used.

For Class A flow conditions through bridges, the recommended pier shape coefficients given in the HEC-2 Users Manual were used. Coefficients were chosen based upon the pier shape which most closely resembled the existing field conditions.

Recommended broad-crested weir coefficients given in the HEC-2 Users Manual were used where flow overtopped the bridge decks.

5. Uncertainty Allowance

Uncertainty allowance is the vertical distance from a design water surface to the top of an excavated channel, levee, or the low chord (lowest point) of a bridge or culvert. The minimum uncertainty allowance above the design water surface profile used for the design of project channels was one foot where flow is confined within a totally excavated channel; three feet where levees exist or are to be constructed or reconstructed; and one foot below low chord through existing bridges/culverts (100-year). An uncertainty allowance of less than one foot below the low chord through existing bridges or culverts for the 200-year was considered acceptable provided the design water surface did not inundate the low chord of the bridge.

If feasibility-level studies are carried out for this project, a risk based evaluation related to uncertainty allowances will be conducted.

6. Slope Protection

In order to determine the need and extent of bank protection for the proposed improvements, channel velocities were computed assessing a 20 percent reduction in the Mannings "n" values used for computing the project design water surface elevations. The resulting velocities were compared with a maximum suggested mean channel velocity for grass-lined earth of around seven feet per second (fps). The maximum velocity was established based upon information contained in the Corps of Engineers publication EM 1110-02-1601, "Hydraulic Design of Flood Control Channels." This limiting velocity is reasonable compared to the design velocities in the 1958 Design Memorandum for the Cache Creek levees, which ranged from 5 ft/sec to 10 ft/sec with the majority of them being 7 ft/sec or greater.

Where slope protection was required, stone riprap protection was designed in accordance with EM 1110-02-1601, "Hydraulic Design of Flood Control Channels."

7. Channel Configuration

Where appropriate, the existing channel will be modified to carry flood flows. The bottom width will be enlarged, side slopes will be 1V:2H, and access will be provided by a 12-foot wide patrol road on each side of the channel.

8. Levee Configuration

Where existing levees are to be raised, the existing water side levee side slope will be maintained, a 12-foot wide patrol road will be constructed on the top of the elevated

levee berm, and the land side levee embankment side slope will be constructed to the same slope (parallel) as the existing land side levee side slope.

Where new levees are constructed, the land side levee slope will be 1V:2H. The water side slope of the new levee embankment will be constructed at 1V:3H. The top width of the levee berm will be 12 feet and will also function as a patrol road. The limits of the right-of-way will extend to the toe of the land side slope of the new levee embankment. A minimum 30-foot berm between the top of bank of the channel and the water side levee toe of slope will normally be maintained unless right-of-way or other limitations exist.

4.03 Development of Alternative Plans

1. Planning Assumption

The formulation and evaluation of alternative flood control plans were based upon the most likely conditions expected to exist in the future. It was assumed that the deficiencies in levee crown elevations identified for portions of Cache Creek levee systems in the Phase IV System Evaluation would not be restored by the Corps of Engineers under the authorization for Restoration of the Sacramento River Flood Control Project. This assumption has been made based upon the following statement from the Phase IV System Evaluation report:

> "About 18 additional miles of levees along Cache Creek, Willow Slough Bypass, and Putah Creek may need reconstruction work to restore levee crown elevations. Subsidence due to ground-water pumping appears likely to have caused levee subsidence, but additional studies by the local sponsor are needed,

since there is no Federal interest at this time if deficiencies are caused by nondesign defects."

2. Technical Studies of Existing Flood Conditions

The following paragraphs describe several of the technical studies which were performed to evaluate existing flood conditions as part of the plan formulation process.

a. Determination of PFP, PNP, and Nondamaging Channel Capacities

In order to determine where flood protection measures are required, the probable failure point (PFP), the probable nonfailure point (PNP), and the nondamaging channel capacity were evaluated for each cross section (excluding bridge cross sections) on Cache Creek. The following definitions were used in the determination of these elevations/capacities. The definitions are based upon historical performance of the existing project levees, as well as private levees along Cache Creek.

- PFP -- Probable Failure Point -- For both Corps of Engineers and private levees, PFP is the top of the levee.

- PNP -- Probable Nonfailure Point -- For Corps of Engineers project levees, PNP is an elevation which is three feet below the top of the levee. For private levees, PNP is an elevation which corresponds to the existing ground elevation.

- Nondamaging Channel Capacity -- In leveed channel reaches, it is the channel capacity at the PNP. In natural channels, it is the channel capacity at the existing ground elevation.

The PFP, PNP, and nondamaging channel capacities were determined by developing a rating curve for each section based upon the results of a multiple HEC-2 run. Table 1, summarizes the PFP, PNP, and the nondamaging channel capacity for each relevant cross section.

Review of Table 1 indicates that the PNP for several sections is below the design flow of 30,000 cfs. A comparison between the top of levee elevations contained in the 1958 Design Memorandum for the Cache Creek levees and the surveyed top of levee elevations obtained for this study indicate the top of levees are lower than designed. The reduction in top of levee elevation would explain a reduced channel capacity. The reduction in elevations could be the result of land subsidence as discussed in the Draft Phase IV of the "Sacramento River Flood Control System Evaluation."

Comparing the PNP and nondamaging channel capacities listed in Table 1 with the peak discharges associated with a storm event of a given return period, indicates the level of protection afforded by the system. The peak discharges for Cache Creek at Capay Dam were estimated to be 56,700 cfs, 63,500 cfs, and 80,900 cfs for 50-, 100-, and 500-year, respectively, using the HEC-1 model.

TABLE 1
WESTSIDE TRIBUTARIES, CA
CACHE CREEK
ESTIMATED PFP, PNP, AND NONDAMAGING CHANNEL CAPACITIES

Station No.	Nearest Landmark	Top of Levee, ft	PFP[2/] Capacity, cfs	Existing Ground Elevation, ft	Freeboard Elevation, ft	PNP of Levee[3/], cfs	Nondamaging Channel Capacity,[4/] cfs
246+00		50.7	62,000	43.0	47.7	43,000	
265+00		50.7	53,000	45.0	47.7	36,000	
274+00		52.7	67,000	44.3	49.7	48,000	
279+40		54.6	65,000	47.0	51.6	47,000	
294+20		54.6	56,000	46.6	51.6	42,000	
315+20		56.6	56,000	51.3	53.6	40,000	
334+50		57.4	47,000	53.3	54.4	31,000	
352+70		60.1	39,000	53.5	57.1	28,000	
372+50		62.5	37,000	57.5	59.5	27,000	
390+80	Highway 113	64.3	35,000	59.6	61.3	26,000	
407+00		67.0	35,000	59.8	64.0	26,000	
427+00		68.9	35,000	61.4	65.9	27,000	
447+70		70.0	33,000	60.7	67.0	25,000	16,000
467+00		72.4	37,000	65.1	69.4	29,000	19,000
490+00		74.2	37,000	66.2	71.2	29,000	19,000
507+00		73.9	35,000	67.1	70.9	27,000	19,000
527+00		77.9	40,500	71.8	74.9	30,000	24,000
546+00		80.5	40,000	73.1	77.5	31,000	22,000
567+70	Interstate 5	82.2	40,000	75.2	79.2	31,000	23,000
586+10		83.5	34,000	77.0	80.5	28,000	22,000
606+70		86.5	38,000	80.0	83.5	31,000	25,000
626+70[1/]		88.8	N/A	86.3	85.8	35,000	35,000
643+00[1/]		89.9	N/A	86.2	86.9	33,000	32,000
660+00				88.0			35,000
679+00				90.0			38,000
696+60				89.5			36,000
712+50				90.1			37,000
728+00				91.1			39,000
756+20				94.0			46,000
771+00				94.0			46,000
790+50				94.8			47,000
811+40				100.0			64,000
821+00				97.5			56,000
830+70				108.5			91,000

1/ Levee along left side only. PFP elevation exceeds existing ground along right bank. Nondamaging channel capacity based upon PNP elevation.
2/ PFP taken at top of levee elevation.
3/ PNP taken at three feet below top of levee elevation.
4/ Nondamaging channel capacity corresponds to top of bank elevation of nonleveed section or adjacent existing ground elevation of leveed section.
File: CACHE2.DAT

TABLE 1
WESTSIDE TRIBUTARIES, CA
CACHE CREEK
ESTIMATED PFP, PNP, AND NONDAMAGING CHANNEL CAPACITIES

Station No.	Nearest Landmark	Top of Levee, ft	PFP Capacity,[2/] cfs	Existing Ground Elevation, ft	Freeboard Elevation, ft	PNP of Levee[3/], cfs	Nondamaging Channel Capacity,[4/] cfs
832+70	Road 94B			101.5			67,000
835+60				102.8			68,000
853+50				108.3			86,000
870+10				108.6			87,000
886+20				110.0			91,000
901+60				114.0			100,000
918+50				117.3			110,000
942+70				116.2			88,000
967+00				121.6			93,000
986+50				123.0			88,000
1005+20				130.0			110,000
1022+40				130.0			94,000
1044+50				137.4			103,000
1060+00				137.1			83,000
1086+90	Highway 505			146.0			>100,000
1130+00				150.0			96,000
1156+50				154.0			100,000
1175+00				158.0			>100,000
1193+50				160.0			>100,000
1217+00				162.1			>110,000
1236+00				166.6			>110,000
1252+70				170.0			>110,000
1271+20	Road 87			172.0			>110,000
1299+70				180.0			>110,000
1323+50				180.0			90,000
1344+00				188.0			110,000
1364+70	Road 85			196.0			78,000
1401+90				205.6			45,500
1421+80				207.3			30,000
1442+00				212.6			35,000
1463+00				218.8			37,000
1484+00				220.4			26,000
1486+00				221.6			29,000
1487+80				222.9			33,000
1490+00				222.0			28,000
1491+80	Capay Dam			228.0			62,000

2/ PFP taken at top of levee elevation.
3/ PNP taken at three feet below top of levee elevation.
4/ Nondamaging channel capacity corresponds to top of bank elevation of nonleveed section or adjacent existing ground elevation of leveed section.
File: CACHE2.DAT

b. Floodplain Mapping

The water surface elevations and floodplains were determined for the 50-, 100-, and 500-year events. The information was used by others in determining flood damages and in this study to identify where flood protection measures are required.

The existing Corps of Engineers HEC-1 model, CACHEC6, which simulates flood flows above Interstate 5 on Cache Creek, was modified for this study. Modifications included: (1) extending the model downstream to the Cache Creek Settling Basin, (2) replacing the CACHE6 Muskingum Routing with Modified Puls to better reflect known storage-outflow functions developed in this study from supplemental cross-sectional information, and (3) further subdividing the study reach of Cache Creek to reflect overflows leaving the system.

Since the 50-, 100-, and 500-year flows were significantly greater than the channel capacity downstream of Road 94B, overtopping occurs along much of the channel. Also the channel is perched downstream of the Road 94B bridge and when overtopping occurs, flow leaves the system (travels overland away from the channel). To model this situation with the HEC-2 computer program, a split flow analysis was made. Where overtopping of a levee occurred, the levee would be failed to existing ground for the entire reach. In overtopping reaches where the adjacent floodplain is relatively flat and uniform, normal depth elevations were used to determine the depth of flow in the overbank, otherwise the weir equation was used in reaches where bank elevations were elevated above adjacent lands.

To begin this analysis, the entire overtopping reach was divided into several subreaches. Starting from the farthest upstream subreach, the HEC-2 model was configured to only let split flow occur in the first subreach assuming the levee failed to the existing ground for the entire subreach. If overtopping still occurred in the downstream reaches, the HEC-2 model would again be modified to allow split flow to occur on the two farthest upstream subreaches. This second HEC-2 simulation would then be rechecked for downstream overtopping flows. This process was repeated, working downstream, until no further overtopping occurred.

Once this point was reached when no further overtopping occurred, the computed water surface elevations (CWSEL) in HEC-2 were compared against the channel's nondamaging elevations. If the CWSEL exceeded the channel's nondamaging elevation (in the case of a leveed section) the levee would be failed to existing ground and the next downstream subreach rechecked for overtopping flows.

Table 2 provides a comparison between the modified HEC-1 and the original HEC-1 model. The modifications have resulted in less flow remaining in the channel.

Approximately 15,200 cfs, 15,300 cfs, or 15,500 cfs (50-, 100-, or 500-year flow rates, respectively) overtop the banks of Cache Creek and flow overland north and south along Road 113.

TABLE 2

ESTIMATED CACHE CREEK PEAK FLOWS

Location	Return Period (yr)	Current B&A HEC-1[1/] (cfs)	Original Corps HEC-1[2/] (cfs)
Capay Dam	500 100 50	80,900 63,500 56,700	80,900 63,500 56,700
Capay Bridge	500 100 50	80,800 63,500 56,700	N/A
Road 94B	500 100 50	81,600 64,000 57,100	N/A
I-5 (Before Diversion)	500 100 50	79,300 62,300 55,600	82,200 64,600 57,700
I-5 (After Diversion)	500 100 50	36,100 35,800 35,600	57,600 56,100 53,100
Yolo (After Diversion)	500 100 50	32,300 32,200 32,000	N/A
Road 113 (Before Diversion)	500 100 50	32,300 32,200 32,000	N/A
Road 113[3/] (After Diversion)	500 100 50	17,000 17,000 17,000	N/A
End of Training Levee[3/]	500 100 50	17,000 17,000 17,000	N/A

[1/] File Name: 1CACHE.DAT

[2/] File Name: CACHE6

[3/] The decrease in flow in the downstream direction reflects flow leaving the system due to channel capacity limitations and the failure of project levees.

N/A: Not Available

Table 3, summarizes the results of the channel overtopping and diversion analysis. To complete the floodplain analysis, the Cache Creek diversions given on Table 3 were used and separate HEC-2 models were developed for each subreach where flows leave the main Cache Creek channel.

c. Volumetric Considerations in Delineating Floodplains

An analysis was completed to verify that the volume of overflow from Cache Creek is sufficient to occupy the floodplains mapped in the vicinity of the City of Woodland. This was accomplished by routing the overflow hydrographs through the area using the modified Puls Routing based upon the floodplain HEC-2 models. The relatively small attenuation in the peak flow indicates that sufficient volume of overflow occurs to support the floodplains.

d. Land Subsidence Considerations

Land subsidence, in varying magnitudes, is known to have occurred in Yolo County generally from Davis to Zamora and in Woodland and the lower areas of Cache Creek. Ground elevations provided by the Corps of Engineers indicate that between 1964 and 1993 approximately 2.5 feet of subsidence occurred in the City of Woodland, while only about 0.5 feet of subsidence occurred east of Woodland near the Yolo Bypass.

The floodplain mapping for the Woodland area was based upon 7.5-Minute Quadrangle maps reflecting topographic information obtained in the early 1950's. The fact that

TABLE 3

CACHE CREEK DIVERSIONS FOR FLOODPLAIN ANALYSIS

Station No.	Return Period (yr)	Left Bank (cfs)	Right Bank (cfs)
756+20	50	200	
	100	700	
712+50	500	3,200	
712+50	50		18,100
	100		24,700
573+44	500		39,000
606+07	50	2,000	
	100	2,200	
573+44	500	2,500	
567+70	50	3,600	
	100	3,700	
546+00	500	3,800	
467+00	50	7,400	7,800
	100	7,400	7,900
401+78	500	7,600	7,900

File: CACHE3E.DAT

land subsidence in the vicinity of Woodland is greater than that which has occurred to the east, raised the concern that the depth and aerial extent of flooding in the City of Woodland could be greater than that estimated using the 1950 topographic information. To address this concern, a HEC-2 analysis was performed with assumptions applied that would simulate the land in the vicinity of Woodland being 2.5 feet lower than land to the east near the Yolo Bypass.

Results of this analysis indicate that subsidence occurring since development of the quadrangle maps used in this study has a limited affect on the depths and areal extent of flooding in the vicinity of the City of Woodland. The reason for this is that the slope of the land, from west to east, is sufficiently steep such that the depths of flooding in Woodland would remain unchanged. The extent to which the depth of flooding is affected under this scenario is illustrated on Plate 10.

3. Description of Preliminary Alternative Plans

Three types of structural flood control measures were used to develop preliminary alternative flood control plans for Cache Creek: upstream detention, channel improvements, and levee modifications/ new levees (see Plate 11 for locations of preliminary alternative plans).

Three detention storage sites were evaluated in the Cache Creek watershed to determine their effectiveness on reducing flood flows. One site on Bear Creek is located about 11 miles upstream from its confluence with Cache Creek. This potential

reservoir site was identified by the Department of Water Resources in the early 1970's as referenced in the report entitled, "Alternative Eel River Projects and Conveyance Routes - Appendix B, Supporting Engineering Studies," dated December 1972.

The second site is located on the main stem of Cache Creek approximately five miles downstream from the North Fork Confluence in Wilson Valley. The Wilson Valley site has been studied by various federal and state agencies.

The California Department of Water Resources conducted a detailed foundation analysis of the Wilson Valley site in the early 1970's as part of the alternative Eel River Project conveyance routes (referenced in the report entitled, "Alternative Eel River Projects and Conveyance Routes - Appendix B, Supporting Engineering Studies," dated December 1972). It was determined that only a dam height of 130 feet could be constructed due to weak foundation conditions. This height would only provide 37,000 acre-feet of storage and it was estimated that this volume would be completely filled with sediment in 80 to 90 years.

The third storage site is located on Cache Creek downstream of Capay Diversion Dam. This site was chosen in order to evaluate the possibility of attenuating flows by diverting from Cache Creek into ponds constructed adjacent to the channel.

Channel improvements (channelization) were investigated between the settling basin (Station 0+00) and Road 94B (Station 831+95), approximately 15.7 miles. This lower reach of Cache Creek is where flood flows overtop existing banks and levees and inundated adjacent lands,

as well as travel overland and flood urbanized areas. See the existing floodplain maps (Plates 3 through 9 in Appendix A).

The channelization improvements investigated were primarily channel widening. Significantly lowering the channel invert, in most situations, was impractical because of the numerous existing bridges which limited invert adjustments. Replacement of existing bridges, except where they have a substantial adverse impact on water surface profiles immediately upstream, was avoided for economic reasons.

Levee modifications and new levee constructions were also evaluated along Cache Creek. Where possible, existing levees on one or both channel banks were elevated to the required berm elevation to contain the design flow within the required uncertainty limit.

In both the channelization and levee modifications/new levee alternatives, aerial photos along with field observations were used to set the centerline alignments. Buildings and other types of improvements were avoided wherever possible and, in many cases, either the channel was widened or a new levee was relocated only to one side of the existing channel (unsymmetrical).

4. Screening of Preliminary Plans

The following paragraphs address the development and preliminary evaluations associated with detention storage, levees, and channelization on Cache Creek. Each type of structural measure, or combination, was evaluated in sufficient detail in order to either drop the concept from

further consideration or refine the plan and carry it forward as a final alternative.

a. Detention Storage

Detention storage on Bear Creek was evaluated by modifying the HEC-1 computer model to reflect storage of 100 percent of the runoff occurring upstream of a reservoir site on Bear Creek. Despite the fact that flood inflows were completely stored on Bear Creek, channel flows downstream in Cache Creek were only reduced by about nine percent. Table 4 illustrates flow rates at Yolo for two scenarios -- with and without maximum storage on Bear Creek.

Based upon the results presented in Table 4, it was concluded that significant reductions in flood flows as a result of storage on Bear Creek is not possible. Therefore, Bear Creek was dropped from further hydrologic/hydraulic analyses. However, due to strong local interest and the lack of an economic comparison between benefits and costs, cost estimates for 100- and 200-year level of detention storage on Bear Creek were developed and are presented in Appendix C.

Detention storage on Cache Creek at Wilson Valley was evaluated by modifying the HEC-1 models to reflect utilization of approximately 37,000 acre-feet of storage during various storm events. This storage volume is the maximum that can be constructed at the Wilson Valley site.

TABLE 4

COMPARISON OF PEAK DISCHARGES OF CACHE CREEK
AT YOLO WITH AND WITHOUT MAXIMUM
DETENTION STORAGE ON BEAR CREEK

Exceedence Interval (yr)	Maximum Storage Volume (ac-ft)	Peak Discharge Without Detention (cfs)	Peak Discharge With Detention (cfs)	Percent Difference With and Without Detention
500	33,000	79,300	72,200	9.0
200	29,000	69,900	63,700	8.9
100	26,000	62,300	56,800	8.8
50	23,000	55,600	50,700	8.8

Table 5 provides a comparison between the peak discharges of Cache Creek at Yolo resulting from no storage and from 37,000 acre-feet of storage at Wilson Valley for various storm events. The percent difference in peak discharges is less than 30 percent and the attenuated flow for the 50-year event of 40,800 cfs is well above the PNP's.

Based upon the results presented in Table 5, it was concluded that significant reductions in flood damages could not be achieved with the storage available at the Wilson site. This conclusion and the estimate that the reservoir would be filled with sediment in less than 100 years resulted in the dropping of the Wilson Valley site from further analysis. The off-stream storage sites, which would be located upstream of Road 94B, were evaluated by modifying the HEC-1 model to reflect storage at the Capay Diversion Dam. The storage volumes necessary to reduce peak discharges at Yolo to 25,000 cfs for various storm events were determined (see Table 6). An allowable peak flow of 25,000 cfs was selected based upon the minimum PNP value for the leveed reach. The area required for off-site detention ponds was estimated using the required storage volumes and assuming a depth of storage of 20 feet (see Table 6). The estimated area requirements ranged from approximately four to ten square miles. Off-stream storage sites were dropped from further analysis due to the large land requirements, as well as construction and operational difficulties.

b. Channel/Levee Improvements

An analysis was completed to determine if the channel capacity could be increased by excavating between the existing levees sufficiently to convey the 100- and

TABLE 5

COMPARISON OF PEAK DISCHARGES OF CACHE CREEK
AT YOLO WITH AND WITHOUT 37,000 ACRE-FEET
DETENTION STORAGE AT WILSON VALLEY

Exceedence Interval (yr)	Peak Discharge[1/] (cfs)	Peak Discharge[2/] (cfs)	Percent Difference With and Without Detention
500	79,300	61,700	22.2
200	69,900	53,200	23.9
100	62,300	46,700	25.0
50	55,600	40,800	26.6

1/ File: 1CACHE.DAT

2/ File: 1WILSON.DAT

TABLE 6

OFF-STREAM DETENTION REQUIREMENTS NECESSARY TO ELIMINATE FLOODING ON CACHE CREEK

Exceedence Interval (yr)	Peak Discharge at Yolo Without Detention (cfs)	Peak Discharge at Yolo With Detention (cfs)	Required Detention Capacity[1/] (ac-ft)	Required Detention Area (sq mi)
500	79,300	25,000	130,000	10.2
200	69,900	25,000	98,000	7.7
100	62,300	25,000	75,000	5.9
50	55,600	25,000	57,000	4.4

[1/] Area based upon an average depth of 20 feet.

200-year events while maintaining an uncertainty allowance of three feet. It was determined that this would not be a feasible alternative. This approach was dropped because insufficient room was available between the levees below Highway 113 to accommodate the necessary excavation and the resulting channel velocities upstream of Highway 113 were excessive, ranging from 11 to 12 fps.

The ability to increase the channel capacity by simply raising the existing levees was also investigated. The results indicated that, in general, levee heights from 12 to 18 feet would be required and the majority of the study reach would have velocities in excess of 7 fps.

Review of the bridge hydraulics in the vicinity of the Interstate 5 crossing of Cache Creek indicated that two of the four bridges (the Southern Pacific Railroad Bridge and the Cacheville Road Bridge) were causing substantial "backwater" effects upstream. In order to minimize excavation and limit any required supplemental levees to reasonable heights, replacement of both bridges was determined to be the best solution. Therefore, the HEC-2 model was modified to reflect two bridge replacements with more hydraulically efficient sections.

The abutments of the abandoned railroad bridge located downstream of Highway 113 were also found to cause substantial "backwater" effects upstream. Therefore, the HEC-2 model was revised to eliminate this constriction.

Based upon the results of the initial channelization analysis, it was determined that a channelized section with levee improvements and selective stone protection in certain areas, where a fully incised channel could not

contain flood flows without excessive excavation, was a more realistic approach to channel improvements. An iterative bottom width/channel velocity selection process was completed to determine required bottom widths to meet the target channel velocity of 7 fps.

Results of this analysis showed that bottom widths in the range of 200-400 feet in most reaches were necessary in order to limit channel velocities to 6-7 fps. Overbank velocities for this situation were in the 3-4 fps range. Replacement of the Southern Pacific Railroad and Cacheville Road bridges, as with the previous evaluation, was found to be appropriate from a hydraulics standpoint. This alternative channelization plan was found to be reasonable and was carried forward as a final alternative (Alternative 1).

As a result of the initial levee raising analysis, it was concluded that just elevating the existing levees was not practical since the entire channel between the levees would require stone protection. A system of setback levees was therefore developed and evaluated.

To determine the appropriate levee setback, aerial photographs were reviewed. A determination was then made if one of the existing bank levees could be elevated and only one new opposite bank levee constructed or if a more symmetrical offset (new levees on both sides of the channel) was necessary because of right-of-way or building considerations. Results of this analysis showed that channel velocities could be lowered with a system of offset levees.

Based upon the results of the preliminary investigations, it was determined that an alternative which used setback levees was reasonable and should be carried forward as a final alternative (Alternative 2).

4.04 Final Alternative Plans

1. Plan Descriptions

a. Alternative 1 -- Channel and Levee Improvements

Based upon preliminary screening results, a viable alternative plan which involved channelizing Cache Creek was identified. The initial analyses indicated that maintaining a target velocity of about 7 fps could be accomplished with bottom widths in the 200- to 400-foot range. Slope protection, however, would be required in certain locations.

In order to finalize this alternative, aerial photos were examined and the channel bottom width was expanded in the direction which caused the least impacts on adjacent improvements (buildings). The HEC-2 computer model was modified to reflect these expanded sections and Mannings "n" values were lowered to 0.035 for the excavated portion of each cross section. Where water surface elevations were less than one foot below the existing low bank elevation or above the low bank, the channel was further widened until both the target water surface elevation was met and the channel velocity dropped to approximately 7 fps.

In the lower reaches of Cache Creek primarily downstream of Station 447+70, supplemental levees were added in place of additional channel widening because an excavation-only section in these reaches became excessively wide.

Hydraulic analysis of both the Southern Pacific Railroad bridge and the Cacheville Road bridge indicated bridge improvements were warranted. Therefore, the Southern Pacific Railroad bridge will be reconstructed to lengthen the bridge from approximately 160 feet to 360 feet. The Cacheville Road bridge will be lengthened from about 205 feet to 330 feet. These new bridges will provide greater clear openings across Cache Creek and substantially reduce water surface elevations upstream during flood events. Profile grades on both structures can remain unchanged.

Table 7 summarizes the project features associated with Alternative 1. Plates 12 and 13 in Appendix A contain a Plan View of Alternative 1. Information on channelized invert elevations, channel slopes, bottom widths, stone protection, and supplemental levees for 100- and 200-year levels of protection is also shown on these plans.

Project features for Alternative 1 start just below the Road 102 Bridge (Station 277+90) to Station 832+70 (upstream of the Road 94B Bridge). Additional improvements are also necessary to contain increased flood flows to the Yolo Bypass below the Road 102 Bridge. Preliminary analyses were carried out for this reach below Road 102 and cost estimates developed. These estimates are included in Appendix B.

TABLE 7

ALTERNATIVE 1 – CHANNEL AND LEVEE IMPROVEMENTS (100-YEAR)
SUMMARY OF PROJECT FEATURES

Station No. (ft)	Bank	Feature	Description
277+90 to 279+90		Riprap Channel	Downstream of Road 102
279+90 to 281+92		Concrete-lined Channel	Road 102 Bridge
281+92 to 283+92		Riprap Channel	Upstream of Road 102
280+72 to 294+20	L	Raise Existing Levee	Raise Levee 1.8 Feet
	R	Construct New Levee	Height: 10.7 Feet
294+20 to 315+20	L&R	Raise Existing Levee	Raise Levee 1.1 to 1.8 Feet
		Improve Channel	Bottom Width 240 Feet
315+20 to 334+50	L	Construct New Levee	Height: 5.2 Feet
	R	Raise Existing Levee	Raise Levee 1.0 Feet
		Improve Channel	Bottom Width 240 Feet
334+50 to 352+30	L	Construct New Levee	Height: 5.7 Feet
		Improve Channel	Bottom Width 240 Feet
352+30 to 366+00	L	Construct New Levee	Height: 4.1 to 5.7 Feet
	R	Riprap Bank	
		Improve Channel	Bottom Width 240 Feet
366+00 to 372+50	L	Construct New Levee	Height: 2.3 Feet
366+00 to 384+00	L	Riprap Bank	
		Improve Channel	Bottom Width 240 Feet
384+00 to 401+00	R	Riprap Bank	
		Improve Channel	Bottom Width 240 Feet
398+50 to 400+50		Riprap Channel	Downstream of Highway 113
400+50 to 401+88		Concrete-lined Channel	Highway 113 Bridge
401+88 to 403+88		Riprap Channel	Upstream of Highway 113
401+38 to 456+00	R	Construct New Levee	Height: 3.0 to 5.0 Feet
		Improve Channel	Bottom Width 240 Feet

TABLE 7

ALTERNATIVE 1 – CHANNEL AND LEVEE IMPROVEMENTS (100-YEAR)
SUMMARY OF PROJECT FEATURES

Station No. (ft)	Bank	Feature	Description
456+00 to 480+00		Improve Channel	Bottom Width 240 Feet
480+00 to 500+00	R	Riprap Bank	
		Improve Channel	Bottom Width 240 Feet
500+00 to 540+00		Improve Channel	Bottom Width 240 Feet
540+00 to 569+95	R	Riprap Bank	
		Improve Channel	Bottom Width 240 Feet
567+45 to 569+45		Riprap Channel	Downstream of SPRR
569+45 to 573+44		Concrete-lined Channel	SPRR, Cacheville Road, and Interstate 5 Bridges
573+44 to 575+44		Riprap Channel	Upstream of Interstate 5 Bridge
572+94 to 600+00	L	Construct New Levee	Height: 5.0 Feet
		Improved Channel	Bottom Width 200 Feet
600+00 to 614+00		Improve Channel	Bottom Width 200 Feet
614+00 to 642+00	R	Riprap Bank	
		Improve Channel	Bottom Width 200 Feet
642+00 to 660+00		Improve Channel	Bottom Width 200 Feet
660+00 to 771+00		Improve Channel	Bottom Width 400 Feet

b. Alternative 2 -- Levee Improvements

Preliminary screening analyses indicated that in order to limit target channel velocities to about 7 fps, levees needed to be set back away from the flood channel in many reaches along Cache Creek.

A series of HEC-2 computer model runs were made to simulate various levee setbacks. Existing Mannings "n" values were reduced approximately 15 percent to reflect deeper flows associated with the levees and an overall average "n" value of 0.04 was used for channel and overbank. A channel velocity of 7 fps and a levee height of 10 feet were initially set as target parameters. Results of these analyses indicated that in many cases, the levees could be relocated to meet the two target parameters. There were subreaches along Cache Creek, however, where these two parameters could not both be met. Flooding in the reach of Cache Creek between the Route 113 and the Interstate 5 bridges, because of the existing channel configuration and bridge hydraulics, was not readily corrected. Levee improvements alone could contain flood flows and minimize erosive velocities; however, levee heights in the 16- to 20-foot range were necessary. Further separating the levees along Cache Creek in this reach did not substantially reduce levee heights.

To correct backwater effects caused by the Route 113 bridge during flood flows and reduce upstream levee heights, the Route 113 bridge was replaced in this alternative. The new Route 113 bridge was elevated approximately two feet such that the low chord elevation was raised to approximately elevation 71.5 feet. With

this new structure, a minimum of one foot of freeboard is maintained between the low chord and the design water surface elevation. By elevating the bridge, the height of the required levees also dropped about one foot. Levee heights upstream of the new Route 113 bridge are still in excess of ten feet (15 to 18 foot range). A further reduction in levee heights was not possible unless extensive channel excavation similar to Alternative 1 is carried out.

Final setback levee alignments were established by attempting to meet several criteria as previously indicated. In addition to a target velocity of seven feet per second and a maximum target levee height of 10 feet, a maximum right-of-way width of approximately 2,000 feet in agricultural areas was used to limit setback distances. In areas where levee heights exceeded 10 feet, levees were offset up to 2,000 feet. In areas where gravel operations are presently adjacent to Cache Creek, levees were set back to match proposed limits (phases) of gravel extractions or other existing or planned boundaries.

Table 8 summarizes the project features associated with Alternative 2. Plates 14 and 15 of Appendix A contain a Plan View of Alternative 2. Information on levee locations and required slope protection for 100- and 200-year levels of protection is also shown on these plates.

Project features for Alternative 2 start just below the Road 102 Bridge (Station 270+00) to Station 811+40 (just below the Road 94B Bridge). Additional improvements are necessary to contain increased flood flows to the Yolo Bypass below the Road 102 Bridge. Preliminary analyses

TABLE 8

ALTERNATIVE 2 – LEVEE IMPROVEMENTS (100-YEAR)
SUMMARY OF PROJECT FEATURES

Station No. (ft)	Bank	Feature	Description
270+00 to 280+40	L	Raise Existing Levee	Raise Levee 1.8 Feet
	R	Construct New Levee	Height: 10.9 Feet
		Riprap Channel	Downstream of Road 102
279+90 to 281+92		Concrete-lined Channel	Road 102 Bridge
281+92 to 283+92		Riprap Channel	Upstream of Road 102
280+72 to 352+70	L	Construct New Levee	Height: 8.3 to 13.8 Feet
	R	Raise Existing Levee	Raise Levee 1.7 to 2.6 Feet
352+70 to 367+00	L	Construct New Levee	Height: 6.6 to 8.3 Feet
	R	Raise Existing Levee	Raise Levee 0.5 to 1.7 Feet
	R	Riprap Bank	
367+00 to 384+50	L	Construct New Levee	Height: 5.5 to 7.5 Feet
	R	Raise Levee	Raise Levee 0.5 to 2.6 Feet
384+50 to 401+00	L	Construct New Levee	Height: 7.5 Feet
	R	Raise Levee	Raise Levee 0.5 to 2.6 Feet
398+50 to 400+50		Riprap Channel	Downstream of Highway 113
400+50 to 401+88		Concrete-lined Channel	Highway 113 Bridge
401+88 to 403+88		Riprap Channel	Upstream of Highway 113
401+38 to 525+60	L	Raise Existing Levee	Raise Levee 5.0 to 8.3 Feet
	R	Construct New Levee	Height: 12.0 to 18.2 Feet
525+60 to 569+95	L	Raise Existing Levee	Raise Levee 2.3 to 3.2 Feet
	L	Riprap Bank	
	R	Construct New Levee	Height: 9.4 to 12.0 Feet
567+45 to 569+45		Riprap Channel	Downstream of SPRR
569+45 to 573+44		Concrete-lined Channel	SPRR, Cacheville Road, and Interstate 5 Bridges

TABLE 8

ALTERNATIVE 2 – LEVEE IMPROVEMENTS (100-YEAR)
SUMMARY OF PROJECT FEATURES

Station No. (ft)	Bank	Feature	Description
573+44 to 575+44		Riprap Channel	Upstream of Interstate 5 Bridge
572+94 to 586+10	L	Construct New Levee	Height: 12.0 Feet
	R	Raise Existing Levee	Raise Levee 2.7 to 6.1 Feet
	R	Riprap Bank	
586+10 to 669+20	L	Construct New Levee	Height: 3.8 to 8.3 Feet
	R	Construct New Levee	Height: 4.2 to 7.6 Feet
	R	Riprap Bank	
669+20 to 790+50	L	Construct New Levee	Height: 2.6 to 9.2 Feet
669+20 to 811+40	R	Construct New Levee	Height: 1.8 to 9.2 Feet

were carried out for this reach below Road 102 and cost estimates developed. These cost estimates are included in Appendix B.

2. Project Features

This section provides a general description of each of the project features used in the development of the various flood control alternatives. The specific features for each alternative are presented in the preceding section entitled, "Plan Descriptions." The project feature categories discussed below are consistent with the Work Breakdown Structure Check List included in Appendix A of the Corps of Engineers' "Cost Estimating Guide for Civil Works," dated February 19, 1993.

a. Lands and Damages

Land required for flood control includes the additional right-of-way necessary for reservoir, channel, and levee improvements proposed for each alternative. Right-of-way requirements were determined based upon the results of the hydraulic analyses and a review of existing and future land use conditions. Existing right-of-way data was obtained from parcel maps.

The additional right-of-way required for channel and levee improvement sections was determined by comparing the proposed width with the existing right-of-way width at each stream station. Lands immediately underneath existing and proposed levee embankments were assumed to be taken in fee.

Channels

The proposed right-of-way for channel cut sections assumes a 12-foot wide patrol road on either side of the channel and 1V:2H side slopes. The right-of-way would extend between the outside edge of each patrol road. See Plate 16 in Appendix A for right-of-way requirements for a typical channelization section.

Levees

The proposed right-of-way for levee embankment sections is based upon providing a 12-foot wide patrol road on top of each levee, 1V:3 side slopes on the water side, and 1V:2 side slopes on the land side. The right-of-way would extend ten feet beyond the land side toe of the levee on either side for maintenance and flood fighting purposes. See Plate 17 for right-of-way requirements for a typical leveed section.

b. Relocations

Relocations include railroad, roadway and bridge demolition and replacement, and utilities such as power cables, siphons, pump houses, gage stations, and irrigation ditches. Railroad, roadway, and bridge demolition and replacement relocations are identified separately for each flood control alternative. For reconnaissance-level purposes, the cost for utility relocations was estimated to be approximately three percent of the levee construction cost, excluding mobilization and demobilization. This percentage is based upon a review of example reconnaissance-level cost estimate data by the Corps of Engineers.

c. Project Roads

Improvements under this category include patrol roads to allow access for inspection, maintenance, and flood fighting operations. In accordance with the Corps of Engineers' EM 1110-2-1913, the proposed patrol roads would be surfaced with four inches of aggregate base course material to permit vehicular access during wet weather without causing detrimental effects to the levee or presenting safety hazards to levee inspection and maintenance personnel. The width of patrol roads proposed along channels and on top of levees is 12 feet.

d. Channels and Canals

Channel improvements involve widening and/or deepening existing channel sections to provide additional flood flow capacity. For unleveed reaches, the amount of channel excavation is based upon providing 1V:2H side slopes and a minimum vertical distance of one foot between the top of the channel slope and the design water surface elevation, as an uncertainty allowance.

Plate 16 shows a typical channel cut section with patrol roads provided on both sides.

Where required, riprap slope protection is provided in accordance with EM 1110-2-1601, for an average channel velocity of 10 feet per second. Riprap protection would consist of an 18-inch layer of angular stone placed on a bedding layer of sand. The stone would have a minimum specific weight of 165 pounds per cubic foot, with an equivalent volume spherical stone diameter of 12 inches and an equivalent stone weight of 86 pounds. For cost

estimating purposes, the equivalent weight of riprap in-place is assumed to be 20 percent less than the specific weight of the stone, or 132 pounds per cubic foot, to account for voids between stones.

In areas where riprap is not required, the disturbed channel slopes would be seeded to provide erosion protection. For cost estimating purposes, the unit amount of seed applied is assumed to be 20 pounds per acre.

This category also includes provisions for cleaning out and lining the channel beneath bridges.

e. Levees

Levee improvements include enlarging an existing embankment to raise a levee and/or constructing a new levee embankment, as required, to provide the necessary level of flood protection. The proposed height of a raised or new levee is based upon providing a three foot minimum uncertainty allowance between the top of the levee and the design water surface elevation. See Plate 18 in Appendix A for typical levee requirements.

The crown of both raised and new levees are provided with a 12-foot clear width to accommodate a patrol road, as described earlier. For preliminary design purposes, a water side slope of 1V:3H and a land side slope of 1V:2H have been used for raised and new levee embankments.

Embankment volumes for raised levee sections are based upon constructing a land side levee enlargement. See Plate 18 in Appendix A for details of levee reconstruction work.

The various aspects of levee construction used to develop reconnaissance-level cost estimates include clearing, grubbing, stripping, inspection trench, embankment, road base, and slope protection. Road base is discussed under Section V.5.05.1.c.

Clearing consists of removing all objectionable matter and/or obstructions above the ground surface; including trees, fall timber, brush, vegetation, loose stone, abandoned structures, fencing, and similar debris. Grubbing includes the removal of all stumps, roots, buried logs, old piling, paving, drains, and other objectionable subsurface matter. Clearing and grubbing would be performed beneath the proposed new embankment foundation. For raised levees, this would include the land side slope of the embankment to be enlarged.

Once the foundation area has been cleared and grubbed, the area would be stripped to a depth of six inches to remove low-growing vegetation, organic topsoil, and other objectionable ground cover. For raised levees, this would include the crown and land side slope of the embankment to be enlarged.

In accordance with EM 1110-2-1913, an inspection trench should be excavated under all new levees to expose or intercept any undesirable underground feature such as old drainpipes, water or sewer lines, animal burrows, or other debris. The trenches should have a base of sufficient width to allow backfill compaction with regular compaction equipment. Trenches should have a minimum depth of 6 feet; side slopes should normally not be steeper than 1V on 1H, with flatter slopes if needed for stability. (See Plate 18.)

Where required, riprap protection would be provided on the water side slope of levee improvements in accordance with EM 1110-2-1601. The parameters for riprap slope protection would be similar to those described earlier for channels. See Plate 19 in Appendix A for details of

slope protection for levee and channelization alternatives. Land side slopes and water side slopes not requiring riprap would be seeded to provide erosion protection similar to channel sections.

f. Project Impacts

Alternatives 1 and 2 would not have significant detrimental upstream hydraulic impacts. See Plates 20 and 21 for a plot of existing project water surface elevations and Alternatives 1 and 2 water surface profiles.

Alternative 1 reduces the existing water surface elevations for flood flows upstream from the project limits (Station 771+00) to Station 942+70. The maximum drop in the water surface occurs just upstream of Station 771+00. The 500-year water surface profile at this location is about 5.7 feet lower with Alternative 1 in place as compared to the existing conditions. The 500-year water surface elevation is 0.04 feet lower than existing conditions just upstream of the Road 94B Bridge (Station 835+60). Velocities through the Road 94B Bridge are increased up to 50 percent under the 500-year flood event. A detailed analysis of the existing bridge, channel bed material, and various transitional sections between the improved channel and the existing channel upstream should be carried out in subsequent studies.

For purposes of this reconnaissance-level study, concrete lining has been placed across the channel between Stations 827+40 and 832+70 (530 feet) to protect the channel from these increased velocities. Riprap has also

been added upstream and downstream of the concrete lining.

Alternative 2 increases the existing water surface elevations for flood flows upstream from the project limits (Station 811+40) to Station 1096+69. The maximum rise in the water surface occurs at Station 811+40. The 500-year water surface profile at this location is about 2.2 feet higher with Alternative 2 in place as compared to the existing conditions. The 500-year water surface elevation is 0.91 feet higher than existing conditions just upstream of the Road 94B Bridge (Station 835+60). These minor increases in water surface elevations upstream of Road 94B increase floodplain widths from 0 to about 90 feet for the 500-year event depending upon location. This represents only up to a six percent increase in water surface width. Since there are no identified flood damages in the reach upstream of Road 94B, Alternative 2 does not negatively impact areas upstream of Road 94B.

Both Alternatives would have similar downstream impacts.

Both Alternative 1 and 2 should have minimal impact on sediment transport and channel stability. Alternative 1 (Channel and Levee Improvements) will, in some locations, have higher channel velocities than normally occur with existing conditions. At these locations, riprap with bedding has been provided. Concrete lining has also been placed beneath all bridges. For Alternative 2 (Levee Improvements) the levees have been set back to accommodate greater in-channel flow rates. Channel velocities have also been kept to at or below existing channel velocities. Where existing velocities have been

exceeded, riprap/bedding or concrete lining have been included to minimize erosion.

Under the Alternatives, 64,000 cfs and 71,900 cfs would be conveyed to the Cache Creek Settling Basin for the 100- and 200-year flood events. The existing design flow of the basin is currently 30,000 cfs. Past studies by the Corps of Engineers indicate that minimal impacts would occur with greater flows into the Cache Creek Settling Basin.

The larger flows would encroach into the design uncertainty allowance for the perimeter levees and the training levee of the Settling Basin. This conclusion is based upon the HEC-2 results, the General Design Memorandum, and the May 1991 Construction Drawing for the Settling Basin enlargement.

Costs for raising the perimeter levees and the training levee have been developed (see Appendix B). Quantities were developed to restore the design uncertainty allowances of 4.0 feet and 2.0 feet for the perimeter levees and the training levee, respectively.

Initial studies have revealed the impacts of the increased flows into the Yolo Bypass to be insignificant based upon preliminary analyses of the timing of the peak flows in Cache Creek with the Yolo Bypass

Alternative 1 will not affect side drainage or interior flood control. Because lands adjacent to Cache Creek generally slope away from the Creek, surface drains will be constructed as required to drain areas adjacent to the setback levees to the creek for Alternative 2.

g. Operation and Maintenance

Operation and maintenance activities will be similar to those currently practiced. Channel capacity will be maintained by the local sponsor by removing minor sediment deposition and vegetation. As required, repairs will be made to levee side slopes and patrol roads as a result of any localized erosion. Debris should be removed from bridge openings.

h. Functional Operation

The ongoing operation and maintenance program should prevent malfunction of both Alternatives 1 and 2. Significant accumulation of debris at the upstream face of the bridges should be avoided during flood events.

Flood events greater than the design flows will result in the encroachment of the water surface into the uncertainty allowance.

i. Hazardous and Toxic Waste

The areas contaminated by hazardous, toxic, and radiological waste (HTRW) were identified by the Corps of Engineers to determine possible disturbance from the proposed project. The HTRW sites that could require special consideration were located using federal, state, and county sources.

Federal lists of HTRW sites (EPA National Priorities List, Federal Register, 9/25/91) showed no superfund sites in the study area. The nearest site is the Sulphur Bank Mercury Mine near Clearlake Oaks, currently under a

long-term cleanup by the EPA. State lists (Hazardous Waste and Substance Sites List or "AB 3750 List," California EPA, 11/2/92) showed a number of tank leaks in the Davis and Woodland areas, but outside the project boundaries. The Yolo County HTRW list identified several sites in Madison, Esparto, Winters, and Rumsey, all outside the project boundaries, and a site in the town of Yolo on County Road 97B adjacent to the project. The hazardous substances on the Yolo site are mostly asbestos and agricultural chemicals, and the site is currently under special county investigation. The potential impact of the project on the Yolo site should be examined in greater detail during future studies.

j. Care of Water

The care of water during construction will only be an issue during the wetter months of the year when there are flows in Cache Creek. The channelization work required for Alternative 1 may require a staged construction approach to work in the channel. Rather than totally excavating the channel to the final invert, it may be necessary to only partially excavate the channel during the rainy season and then finish the lower excavation stages during the dry months of the year.

Concrete lining, riprap, and bridge replacement work associated with Alternatives 1 and 2 may also require construction work on bridges to occur only during the dry season.

SECTION 5 -- COST ESTIMATES

5.01 Summary of Costs

Table 9 provides a summary of the total first costs, investments costs, and annual costs. The costs are broken down above and below Road 102. Appendix B contains detailed cost estimates for required improvements below Road 102.

5.02 Basis of Estimates

Separate cost estimates have been prepared for Alternatives 1 and 2 for 100- and 200-year level of flood protection.

1. First Cost

The first costs for flood control improvements presented in this section are reconnaissance-level estimates that have been prepared using unit costs developed for similar projects in the same general area. Where applicable, unit cost data and other information from the Corps of Engineers were used to prepare the cost estimates. For those features where unit cost data was not available, the following sources were used: unit construction costs developed by Borcalli & Associates, Inc. for similar facilities; CalTrans contract cost data; and site work cost data published by R. S. Means Company, Inc. All costs are based upon October 1993 price levels, according to the study scope of work.

Costs for the acquisition of land are based upon real estate valuation estimates developed by Wirth Real Estate for the specific areas concerned. A detailed real estate report is included in Appendix D.

TABLE 9

COST ESTIMATE SUMMARY

Level of Flood Protection	Total Costs, $	
	Alternative 1	Alternative 2
100-Year		
First Cost	84,240,000	49,020,000
Investment Cost	91,120,000	53,020,000
Annual Cost	7,427,000	4,426,000
200-Year		
First Cost	90,400,000	53,980,000
Investment Cost	97,770,000	58,390,000
Annual Cost	7,967,000	4,863,000

Level of Flood Protection	Total Costs Above Road 102, $		Total Costs Below Road 102[1/], $	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
100-Year				
First Cost	80,440,000	45,190,000	3,800,000	3,830,000
Investment Cost	87,010,000	48,870,000	4,110,000	4,150,000
Annual Cost	7,051,000	4,048,000	376,000	378,000
200-Year				
First Cost	85,460,000	48,980,000	4,940,000	5,000,000
Investment Cost	92,430,000	52,980,000	5,340,000	5,410,000
Annual Cost	7,492,000	4,384,000	475,000	479,000

[1/] See Appendix B for cost estimates.

The cost for utility relocations has been estimated to be approximately three percent of the construction cost for levees, excluding mobilization and demobilization, since these features would have the greatest impact on existing utilities. Mobilization and demobilization have been estimated to be approximately one-half of one percent of the construction cost for the feature to which it applies.

Fish and wildlife mitigation costs and cultural resources preservation costs were assessed at 10 percent and one percent of the construction costs, respectively. These percentages are based upon costs experienced on similar projects.

Planning, engineering, and design costs; and construction management costs have been calculated at 14 percent and eight percent, respectively, of the total estimated construction cost (excluding real estate). These percentages are based upon costs experienced by the Sacramento District Corps of Engineers for similar projects.

A contingency of 35 percent has been applied to easement costs. A contingency amount of 25 percent has been applied to the first cost items under the following account categories: reservoirs, channels and canals, and levees and floodwalls. A contingency amount of 20 percent has been applied to the first cost items under the remaining categories of relocations and project roads. This lower contingency was used for these items since these features could be developed by preliminary engineering design computations.

2. Investment and Annual Costs

Investment costs reflect interest during an estimated construction period of two years for both Alternatives 1 and 2. An interest rate of eight percent was used.

Annual cost estimates include interest, amortization, and operations and maintenance. First costs have been amortized at 8.0 percent over a 100-year period. Operations and maintenance costs have been developed for applicable features based upon experience on other projects.

First costs, investment costs, and annual costs are presented on Tables 10 through 13 for Alternatives 1 and 2.

Table 10

ALTERNATIVE 1 – CACHE CREEK CHANNEL AND LEVEE IMPROVEMENTS ABOVE ROAD 102 100-YEAR FLOOD PROTECTION COST ESTIMATE

FIRST COST

Acct. No.	Description	Estimated Quantity	Unit	Unit Cost, $	Extended Cost, $	Contingency $	Contingency %	Total Cost, $
01	LANDS AND DAMAGES							
	Fee	648	ac		2,840,400	994,140	35	3,834,540
	Acquisition Allowance	1	ls	1,500,000.00	1,500,000	0	0	1,500,000
	Total - Lands and Damages				4,340,400	994,140		5,334,540
02	RELOCATIONS							
	Railroad Bridge Replacement	340	lf	5,500.00	1,870,000	374,000	20	2,244,000
	Bridge Replacement	7,630	sf	110.00	839,300	167,860	20	1,007,160
	Utilities	1	ls	17,000.00	17,000	3,400	20	20,400
	Total - Relocations				2,726,300	545,260		3,271,560
06	FISH & WILDLIFE MITIGATION	10	%					5,546,280
	Total - Mitigation							5,546,280
08	PROJECT ROADS							
	Patrol Road	25,540	ton	12.50	319,250	63,850	20	383,100
	Total - Project Roads				319,250	63,850		383,100
09	CHANNELS AND CANALS							
	Mobilization and Demobilization	1	ls	203,000.00	203,000	50,750	25	253,750
	Excavation	12,054,680	cy	2.75	33,150,370	8,287,590	25	41,437,960
	Concrete Channel Lining	10,730	cy	275.00	2,950,750	737,690	25	3,688,440
	Riprap 1/	131,690	ton	26.00	3,423,940	855,990	25	4,279,930
	Bedding 1/	54,540	ton	21.00	1,145,340	286,340	25	1,431,680
	Total - Channels and Canals				40,873,400	10,218,360		51,091,760
11	LEVEES AND FLOODWALLS							
	Mobilization and Demobilization	1	ls	3,000.00	3,000	750	25	3,750
	Clearing and Grubbing	18	ac	310.00	5,580	1,400	25	6,980
	Stripping	21	ac	470.00	9,870	2,470	25	12,340
	Embankment	105,688	cy	5.00	528,440	132,110	25	660,550
	Seeding	14	ac	1,870.00	26,180	6,550	25	32,730
	Total - Levees and Floodwalls				573,070	143,280		716,350
18	CULTURAL RESOURCES PRESERVATION	1	%					554,630
	Total - Cultural Resources							554,630
	Total Construction Cost							66,898,220
30	PLANNING, ENGINEERING, AND DESIGN	14	%					8,617,500
31	CONSTRUCTION MANAGEMENT	8	%					4,924,280
	TOTAL FIRST COST							80,440,000

1/ Riprap and bedding quantities shown under Account No. 09 are the totals for both channels and levees.

Table 10
(continued)

ALTERNATIVE 1 – CACHE CREEK CHANNEL AND LEVEE IMPROVEMENTS ABOVE ROAD 102 100-YEAR FLOOD PROTECTION COST ESTIMATE

INVESTMENT COST

	Description	Estimated Quantity	Unit		Total Cost, $
	INTEREST DURING CONSTRUCTION				
	Interest Rate	8.0	%		
	Construction Period	2	yr		
	Year 0.5 (Midpoint of 1st Year)				
	Uniform Construction Expenditure				40,220,000
	Interest During Construction	0.0400	factor		1,610,000
	Year 1.5 (Midpoint of 2nd Year)				
	Uniform Construction Expenditure				40,220,000
	Interest During Construction	0.1232	factor		4,960,000
	TOTAL INVESTMENT COST				87,010,000

ANNUAL COST

	Description	Estimated Quantity	Unit	Unit Cost, $	Total Cost, $
	INTEREST AND AMORTIZATION				
	Interest Rate	8.0	%		
	Amortization Period	100	yr		6,964,000
	OPERATION AND MAINTENANCE				
	Patrol Roads	18.6	mi	500.00	9,000
	Channel Maintenence	9.3	mi	1,500.00	14,000
	Riprap	25	ac	1,650.00	41,000
	Levees	6.4	mi	3,500.00	22,000
		3.9	mi/ft-height	50.00	1,000
	TOTAL ANNUAL COST				7,051,000

Table 11

ALTERNATIVE 1 – CACHE CREEK CHANNEL AND LEVEE IMPROVEMENTS ABOVE ROAD 102 200-YEAR FLOOD PROTECTION COST ESTIMATE

FIRST COST

Acct. No.	Description	Estimated Quantity	Unit	Unit Cost, $	Extended Cost, $	Contingency $	Contingency %	Total Cost, $
01	LANDS AND DAMAGES							
	Fee	730	ac		3,520,100	1,232,040	35	4,752,140
	Acquisition Allowance	1	ls	1,500,000.00	1,500,000	0	0	1,500,000
	Total - Lands and Damages				5,020,100	1,232,040		6,252,140
02	RELOCATIONS							
	Railroad Bridge Replacement	340	lf	5,500.00	1,870,000	374,000	20	2,244,000
	Bridge Replacement	7,630	sf	110.00	839,300	167,860	20	1,007,160
	Utilities	1	ls	27,000.00	27,000	5,400	20	32,400
	Total - Relocations				2,736,300	547,260		3,283,560
06	FISH & WILDLIFE MITIGATION	10	%					5,849,360
	Total - Mitigation							5,849,360
08	PROJECT ROADS							
	Patrol Road	25,540	ton	12.50	319,250	63,850	20	383,100
	Total - Project Roads				319,250	63,850		383,100
09	CHANNELS AND CANALS							
	Mobilization and Demobilization	1	ls	214,000.00	214,000	53,500	25	267,500
	Excavation	12,770,760	cy	2.75	35,119,590	8,779,900	25	43,899,490
	Concrete Channel Lining	10,760	cy	275.00	2,959,000	739,750	25	3,698,750
	Riprap 1/	134,240	ton	26.00	3,490,240	872,560	25	4,362,800
	Bedding 1/	55,590	ton	21.00	1,167,390	291,850	25	1,459,240
	Total - Channels and Canals				42,950,220	10,737,560		53,687,780
11	LEVEES AND FLOODWALLS							
	Mobilization and Demobilization	1	ls	5,000.00	5,000	1,250	25	6,250
	Clearing and Grubbing	24	ac	310.00	7,440	1,860	25	9,300
	Stripping	27	ac	470.00	12,690	3,170	25	15,860
	Embankment	169,756	cy	5.00	848,780	212,200	25	1,060,980
	Seeding	20	ac	1,870.00	37,400	9,350	25	46,750
	Total - Levees and Floodwalls				911,310	227,830		1,139,140
18	CULTURAL RESOURCES PRESERVATION	1	%					584,940
	Total - Cultural Resources							584,940
	Total Construction Cost							71,180,020
30	PLANNING, ENGINEERING, AND DESIGN	14	%					9,087,260
31	CONSTRUCTION MANAGEMENT	8	%					5,192,720
	TOTAL FIRST COST							85,460,000

1/ Riprap and bedding quantities shown under Account No. 09 are the totals for both channels and levees.

Table 11
(continued)

ALTERNATIVE 1 – CACHE CREEK CHANNEL AND LEVEE IMPROVEMENTS ABOVE ROAD 102 200-YEAR FLOOD PROTECTION COST ESTIMATE

INVESTMENT COST

	Description	Estimated Quantity	Unit		Total Cost, $
	INTEREST DURING CONSTRUCTION				
	Interest Rate	8.0	%		
	Construction Period	2	yr		
	Year 0.5 (Midpoint of 1st Year)				
	Uniform Construction Expenditure				42,730,000
	Interest During Construction	0.0400	factor		1,710,000
	Year 1.5 (Midpoint of 2nd Year)				
	Uniform Construction Expenditure				42,730,000
	Interest During Construction	0.1232	factor		5,260,000
	TOTAL INVESTMENT COST				92,430,000

ANNUAL COST

	Description	Estimated Quantity	Unit	Unit Cost, $	Total Cost, $
	INTEREST AND AMORTIZATION				
	Interest Rate	8.0	%		
	Amortization Period	100	yr		7,398,000
	OPERATION AND MAINTENANCE				
	Patrol Roads	18.6	mi	500.00	9,000
	Channel Maintenence	9.3	mi	1,500.00	14,000
	Riprap	26	ac	1,650.00	43,000
	Levees	7.5	mi	3,500.00	26,000
		4.8	mi/ft-height	50.00	2,000
	TOTAL ANNUAL COST				7,492,000

Table 12

ALTERNATIVE 2 – CACHE CREEK LEVEE IMPROVEMENTS ABOVE ROAD 102 100-YEAR FLOOD PROTECTION COST ESTIMATE

FIRST COST

Acct. No.	Description	Estimated Quantity	Unit	Unit Cost, $	Extended Cost, $	Contingency $	Contingency %	Total Cost, $
01	LANDS AND DAMAGES							
	Fee	1,643	ac		10,385,300	3,634,860	35	14,020,160
	Acquisition Allowance	1	ls	1,500,000.00	1,500,000	0	0	1,500,000
	Total - Lands and Damages				11,885,300	3,634,860		15,520,160
02	RELOCATIONS							
	Railroad Bridge Replacement	340	lf	5,500.00	1,870,000	374,000	20	2,244,000
	Roadway Paved	7,200	sy	21.00	151,200	30,240	20	181,440
	BridgeReplacement	17,890	sf	110.00	1,967,900	393,580	20	2,361,480
	Utilities	1	ls	214,000.00	214,000	42,800	20	256,800
	Residential	1	ls	90,000.00	90,000	0	0	90,000
	Total - Relocations				4,293,100	840,620		5,133,720
06	FISH & WILDLIFE MITIGATION	10	%					2,191,090
	Total - Mitigation							2,191,090
08	PROJECT ROADS							
	Patrol road	26,560	ton	12.50	332,000	66,400	20	398,400
	Total - Project Roads				332,000	66,400		398,400
09	CHANNELS AND CANALS							
	Mobilization and Demobilization	1	ls	30,000.00	30,000	7,500	25	37,500
	Concrete Channel Lining	8,270	cy	275.00	2,274,250	568,560	25	2,842,810
	Railroad Abutment Demolition	1	ls	35,000.00	35,000	8,750	25	43,750
	Riprap 1/	103,745	ton	26.00	2,697,370	674,340	25	3,371,710
	Bedding 1/	42,970	ton	21.00	902,370	225,590	25	1,127,960
	Total - Channels and Canals				5,938,990	1,484,740		7,423,730
11	LEVEES AND FLOODWALLS							
	Mobilization and Demobilization	1	ls	36,000.00	36,000	9,000	25	45,000
	Clearing and Grubbing	123	ac	310.00	38,130	9,530	25	47,660
	Stripping	133	ac	470.00	62,510	15,630	25	78,140
	Embankment	1,364,344	cy	5.00	6,821,720	1,705,430	25	8,527,150
	Seeding	110	ac	1,870.00	205,700	51,430	25	257,130
	Total - Levees and Floodwalls				7,164,060	1,791,020		8,955,080
18	CULTURAL RESOURCES PRESERVATION	1	%					219,110
	Total - Cultural Resources							219,110
	Total Construction Cost							39,841,290
30	PLANNING, ENGINEERING, AND DESIGN	14	%					3,403,730
31	CONSTRUCTION MANAGEMENT	8	%					1,944,980
	TOTAL FIRST COST							45,190,000

1/ Riprap and bedding quantities shown under Account No. 09 are the totals for both channels and levees.

Table 12
(continued)

ALTERNATIVE 2 – CACHE CREEK
LEVEE IMPROVEMENTS
ABOVE ROAD 102
100-YEAR FLOOD PROTECTION
COST ESTIMATE

INVESTMENT COST

	Description	Estimated Quantity	Unit		Total Cost, $
	INTEREST DURING CONSTRUCTION				
	Interest Rate	8.0	%		
	Construction Period	2	yr		
	Year 0.5 (Midpoint of 1st Year)				
	Uniform Construction Expenditure				22,595,000
	Interest During Construction	0.0400	factor		900,000
	Year 1.5 (Midpoint of 2nd Year)				
	Uniform Construction Expenditure				22,595,000
	Interest During Construction	0.1232	factor		2,780,000
	TOTAL INVESTMENT COST				48,870,000

ANNUAL COST

	Description	Estimated Quantity	Unit	Unit Cost, $	Total Cost, $
	INTEREST AND AMORTIZATION				
	Interest Rate	8.0	%		
	Amortization Period	100	yr		3,911,000
	OPERATION AND MAINTENANCE				
	Patrol Roads	19.3	mi	500.00	10,000
	Riprap	24	ac	1,650.00	40,000
	Levees	22.1	mi	3,500.00	77,000
		9.1	mi/ft-height	50.00	10,000
	TOTAL ANNUAL COST				4,048,000

Table 13

ALTERNATIVE 2 – CACHE CREEK LEVEE IMPROVEMENTS ABOVE ROAD 102 200-YEAR FLOOD PROTECTION COST ESTIMATE

FIRST COST

Acct. No.	Description	Estimated Quantity	Unit	Unit Cost, $	Extended Cost, $	Contingency $	Contingency %	Total Cost, $
01	LANDS AND DAMAGES							
	Fee	1,651	ac		10,419,900	3,646,970	35	14,066,870
	Acquisition Allowance	1	ls	1,500,000.00	1,500,000	0	0	1,500,000
	Total - Lands and Damages				11,919,900	3,646,970		15,566,870
02	RELOCATIONS							
	Railroad Bridge Replacement	340	lf	5,500.00	1,870,000	374,000	20	2,244,000
	Roadway Paved	7,200	sy	21.00	151,200	30,240	20	181,440
	Bridge Replacement	17,890	sf	110.00	1,967,900	393,580	20	2,361,480
	Utilities	1	ls	268,000.00	268,000	53,600	20	321,600
	Residential	1	ls	90,000.00	90,000	0	0	90,000
	Total - Relocations				4,347,100	851,420		5,198,520
06	FISH & WILDLIFE MITIGATION	10	%					2,467,640
	Total - Mitigation							2,467,640
08	PROJECT ROADS							
	Patrol Road	26,560	ton	12.50	332,000	66,400	20	398,400
	Total - Project Roads				332,000	66,400		398,400
09	CHANNELS AND CANALS							
	Mobilization and Demobilization	1	ls	31,000.00	31,000	7,750	25	38,750
	Concrete ChannelLining	8,270	cy	275.00	2,274,250	568,560	25	2,842,810
	Railroad Abutment Demolition	1	ls	35,000.00	35,000	8,750	25	43,750
	Riprap 1/	113,355	ton	26.00	2,947,230	736,810	25	3,684,040
	Bedding 1/	46,950	ton	21.00	985,950	246,490	25	1,232,440
	Total - Channels and Canals				6,273,430	1,568,360		7,841,790
11	LEVEES AND FLOODWALLS							
	Mobilization and Demobilization	1	ls	45,000.00	45,000	11,250	25	56,250
	Clearing and Grubbing	139	ac	310.00	43,090	10,770	25	53,860
	Stripping	149	ac	470.00	70,030	17,510	25	87,540
	Embankment	1,718,900	cy	5.00	8,594,500	2,148,630	25	10,743,130
	Seeding	127	ac	1,870.00	237,490	59,370	25	296,860
	Total - Levees and Floodwalls				8,990,110	2,247,530		11,237,640
18	CULTURAL RESOURCES PRESERVATION	1	%					246,760
	Total - Cultural Resources							246,760
	Total Construction Cost							42,957,620
30	PLANNING, ENGINEERING, AND DESIGN	14	%					3,832,430
31	CONSTRUCTION MANAGEMENT	5	%					2,189,950
	TOTAL FIRST COST							48,980,000

1/ Riprap and bedding quantities shown under Account No. 09 are the totals for both channels and levees

Table 13
(continued)

ALTERNATIVE 2 – CACHE CREEK
LEVEE IMPROVEMENTS
ABOVE ROAD 102
200-YEAR FLOOD PROTECTION
COST ESTIMATE

INVESTMENT COST

	Description	Estimated Quantity	Unit		Total Cost, $
	INTEREST DURING CONSTRUCTION				
	Interest Rate	8.0	%		
	Construction Period	2	yr		
	Year 0.5 (Midpoint of 1st Year)				
	Uniform Construction Expenditure				24,490,000
	Interest During Construction	0.0400	factor		980,000
	Year 1.5 (Midpoint of 2nd Year)				
	Uniform Construction Expenditure				24,490,000
	Interest During Construction	0.1232	factor		3,020,000
	TOTAL INVESTMENT COST				52,980,000

ANNUAL COST

	Description	Estimated Quantity	Unit	Unit Cost, $	Total Cost, $
	INTEREST AND AMORTIZATION				
	Interest Rate	8.0	%		
	Amortization Period	100	yr		4,240,000
	OPERATION AND MAINTENANCE				
	Patrol Roads	19.3	mi	500.00	10,000
	Riprap	26	ac	1,650.00	43,000
	Levees	22.5	mi	3,500.00	79,000
		10.3	mi/ft-height	50.00	12,000
	TOTAL ANNUAL COST				4,384,000

SECTION 6 -- BIBLIOGRAPHY

1. Borcalli & Associates; "Covell Drainage System Comprehensive Drainage Plan WMP-92-01-3," October 1992.

2. Cunningham Engineering; "Annual In-Channel Mining Report, Spring 1993," Topographic Maps dated April 10, 1993.

3. Dames & Moore; "Draft Program Environmental Impact Report, Cache Creek Aggregate Resources, Mining Activities and Policy Alternatives," prepared for County of Yolo, May 30, 1991.

4. Dodson & Associates, Inc.; "ProHEC1," The Dodson Professional HEC-1 System - An Enhanced Version of the Standard Corps of Engineers' Watershed Modeling Computer Program, dated April 1991.

5. Dodson & Associates, Inc.; "ProHEC2," The Dodson Professional HEC-2 System An Enhanced Version of the Standard Corps of Engineers' Watershed Modeling Computer Program, dated April 1991.

6. Federal Emergency Management Agency; Flood Insurance Study, Yolo County, California, Incorporated Areas; Revised May 17, 1988.

7. Lustig, Lawrence, and Robert Busch; "Professional Paper 562-A," 1967, paper prepared for the U. S. Department of the Interior, U. S. Geological Survey.

8. Rivertech, Inc.; "Assessment of Impact of Proposed Mining on Bank Protection and Erosion Control for Cache Creek," Parcels 49-470-10, 49-470-11, 49-140-11, and 48-140-20, September 7, 1989.

9. Roger Foott Associates, Inc.; Geotechnical Assessment of Levees in the Mid-Valley Area, Sacramento River Flood Control System Evaluation; December 21, 1989.

10. Simons, Li & Associates, Inc; "Draft Evaluation of The Physical Element of the Resources Management Plan for the Area Along Cache Creek Between Capay and Yolo in Yolo County, California," January 1986.

11. Simons, Li & Associates, Inc.; "Geomorphic Analysis of Cache Creek Between Rumsey and Madison, Yolo County, California," Phase I Final Report, July 30, 1987.

12. Soil Conservation Service, U. S. Department of Agriculture; Soil Survey of Yolo County, California; June 1972.

13. State of California, Department of Water Resources; Bulletin No. 90; Clear Lake - Cache Creek Basin Investigation; March 1961.

14. State of California, Department of Water Resources; "Investigation of Alternative Plans for Control of Sediment From Cache Creek," Memorandum Report, December 1968.

15. State of California, Department of Water Resources; Alternative Eel River Projects and Conveyance Routes, Appendix B, Supporting Engineering Studies; December 1972.

16. U. S. Department of the Army, Corps of Engineers ; "Cache Creek Basin California, Feasibility Report and Environmental Statement for Water Resources Development," September 1978.

17. U. S. Department of the Army, Corps of Engineers; Design Memorandum No. 10, Cache Creek, Yolo Bypass to High Ground Levee Construction; November 1, 1958.

18. U. S. Department of the Army, Corps of Engineers; Information Brochure "Investigation for Flood Control and Related Purposes, Cache Creek Basin, California," November 1975.

19. U. S. Department of the Army, Corps of Engineers; Design Memorandum No. 1 - Cache Creek Settling Basin - Final General Design Memorandum; January 1987.

20. U. S. Department of the Army, Corps of Engineers; "Hydraulic Design of Flood Control Channels," EM 1110-2-1601; Washington, D.C., dated July 1991.

21. U. S. Department of the Army, Corps of Engineers; Sacramento River Flood Control System Evaluation, Initial Appraisal Report - Mid-Valley Area; December 1991.

22. U. S. Department of the Army, Corps of Engineers; Reconnaissance Report - Yolo Bypass, California; March 1992.

23. U. S. Department of the Army, Corps of Engineers; Project Modification Report and Environmental Assessment/Initial Study - Yolo Basin Wetlands, Sacramento River, California; April 1992.

24. U. S. Department of the Army, Corps of Engineers; "Cost Estimating Guide for Civil Works," February 19, 1993.

25. U. S. Department of the Army, Corps of Engineers; R3 Pre-Conference Material - Northern California Streams, Westside Tributaries to Yolo Bypass, California; November 1993.

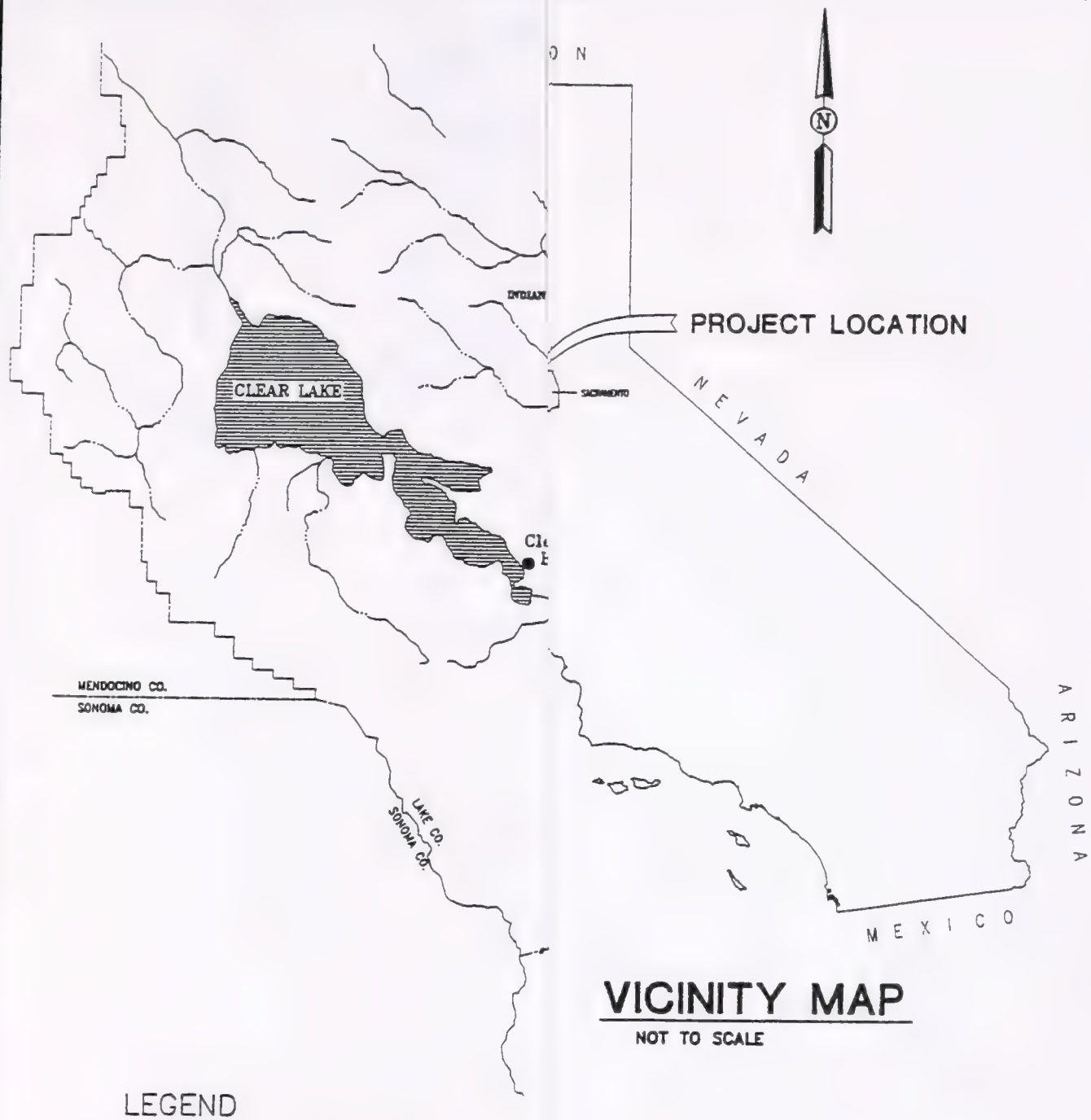
26. U. S. Department of the Interior, Fish and Wildlife Service; Reconnaissance Planning Report, "Fish and Wildlife Resource Management Options for Lower Putah Creek, California," August 1993.

27. U. S. Department of the Interior, U. S. Geological Survey; "Streamflow, Sediment Discharge, and Streambank Erosion in Cache Creek, Yolo County, California, 1953-86," 1989.

28. U. S. Department of the Interior, U. S. Geological Survey; Water Supply Paper 2339, "Guide for Selecting Mannings Roughness Coefficient for Natural Channels and Flood Plains."

29. Water Engineering and Technology, Inc.; "Cache Creek Erosion Mitigation Alternatives," report to the U. S. Army Corps of Engineers, Sacramento District, Contract No. DACW05-88-D-0044, Delivery Order 0003, 1989.

APPENDIX A
PLATES



VICINITY MAP

NOT TO SCALE

LEGEND

..... PROJECT LEVEES

WESTSIDE TRIBUTARIES TO
YOLO BYPASS INVESTIGATION

LOCATION MAP

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 1

VICINITY MAP

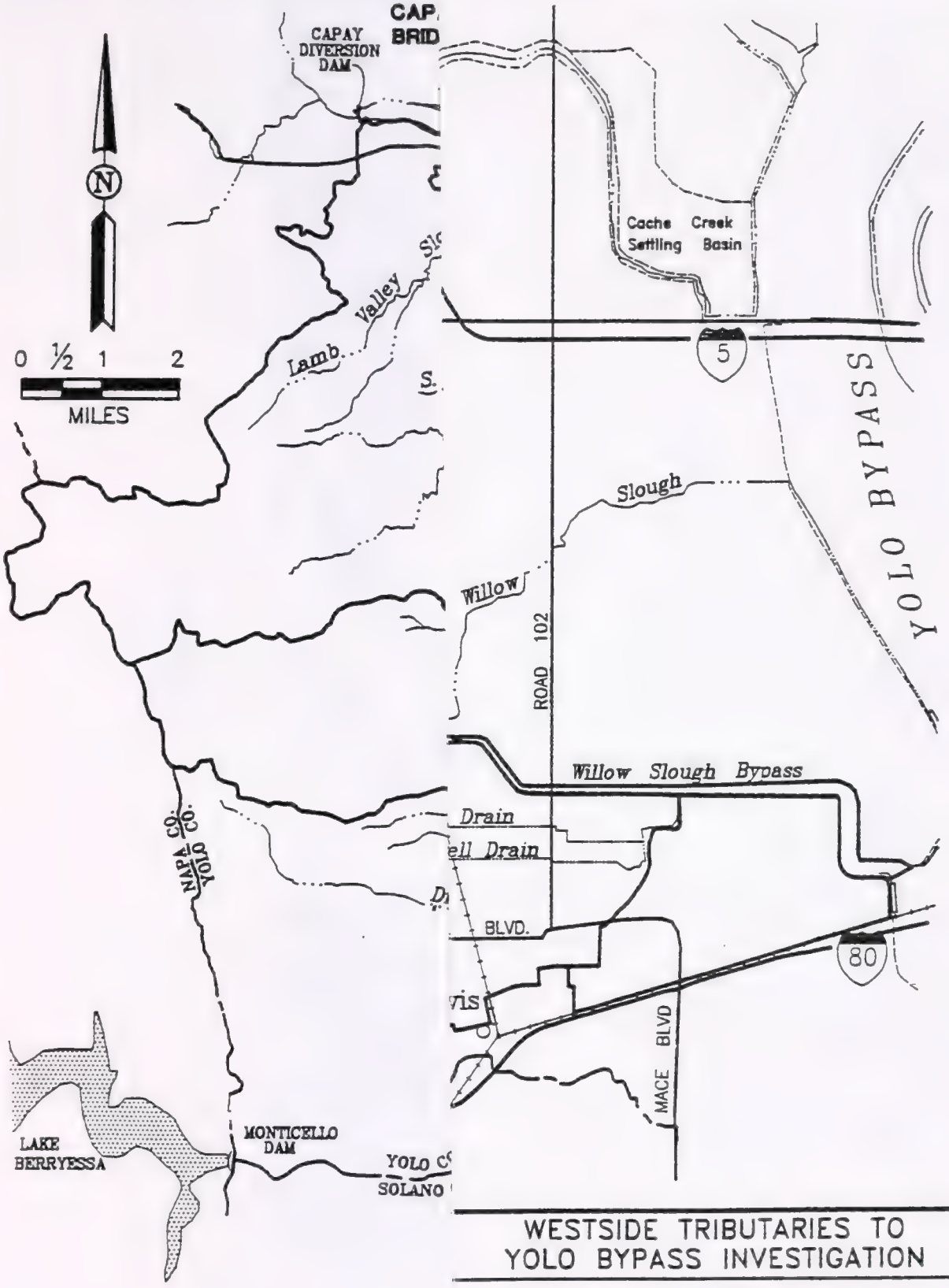
NOT TO SCALE

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

LOCATION MAP

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 1

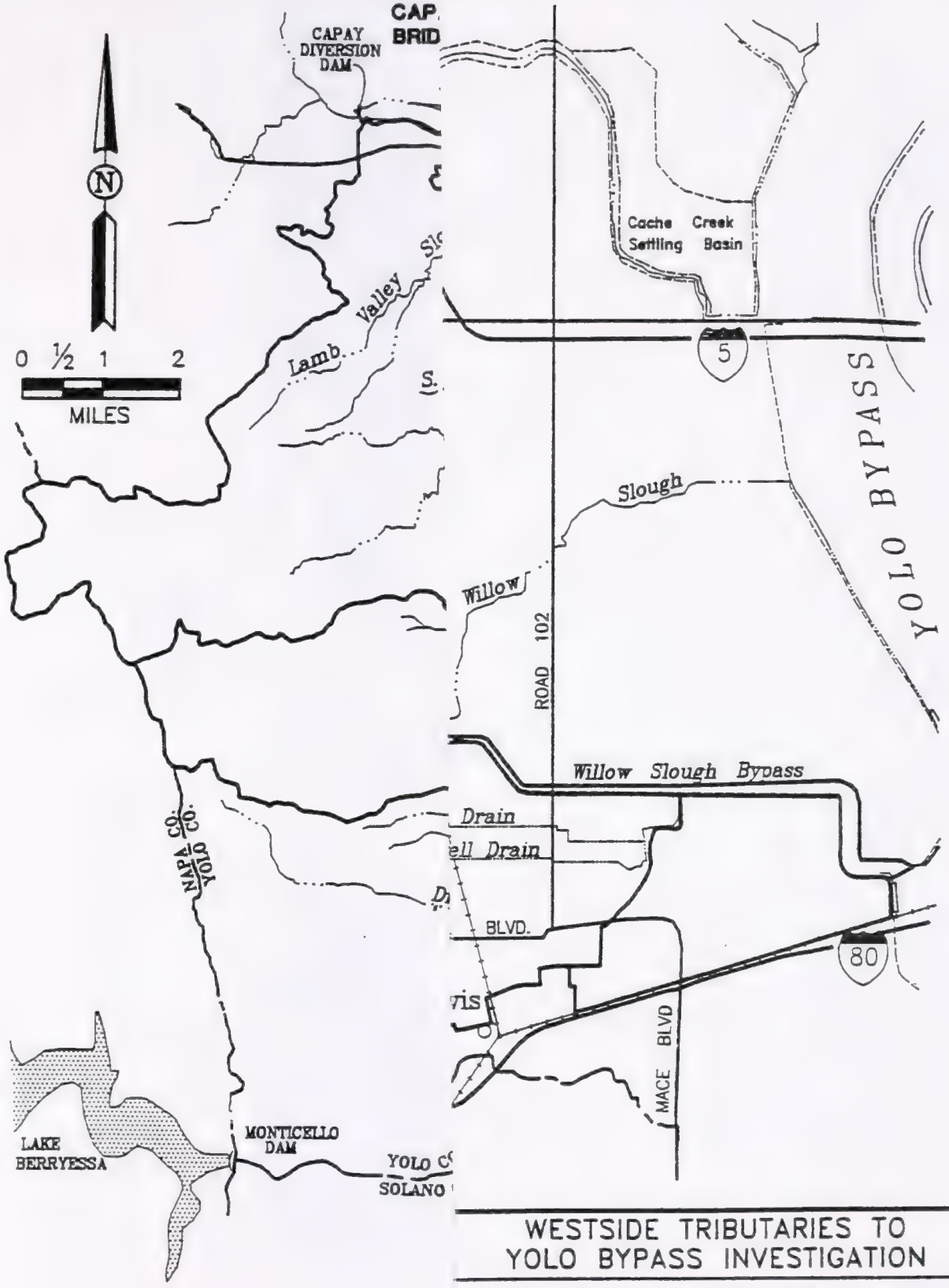


WESTSIDE TRIBUTARIES TO
YOLO BYPASS INVESTIGATION

WILLOW SLOUGH BYPASS BASIN

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

ATE: MARCH, 1994 | PLATE: 2



LEGEND

PRINCIPAL WATERSHE

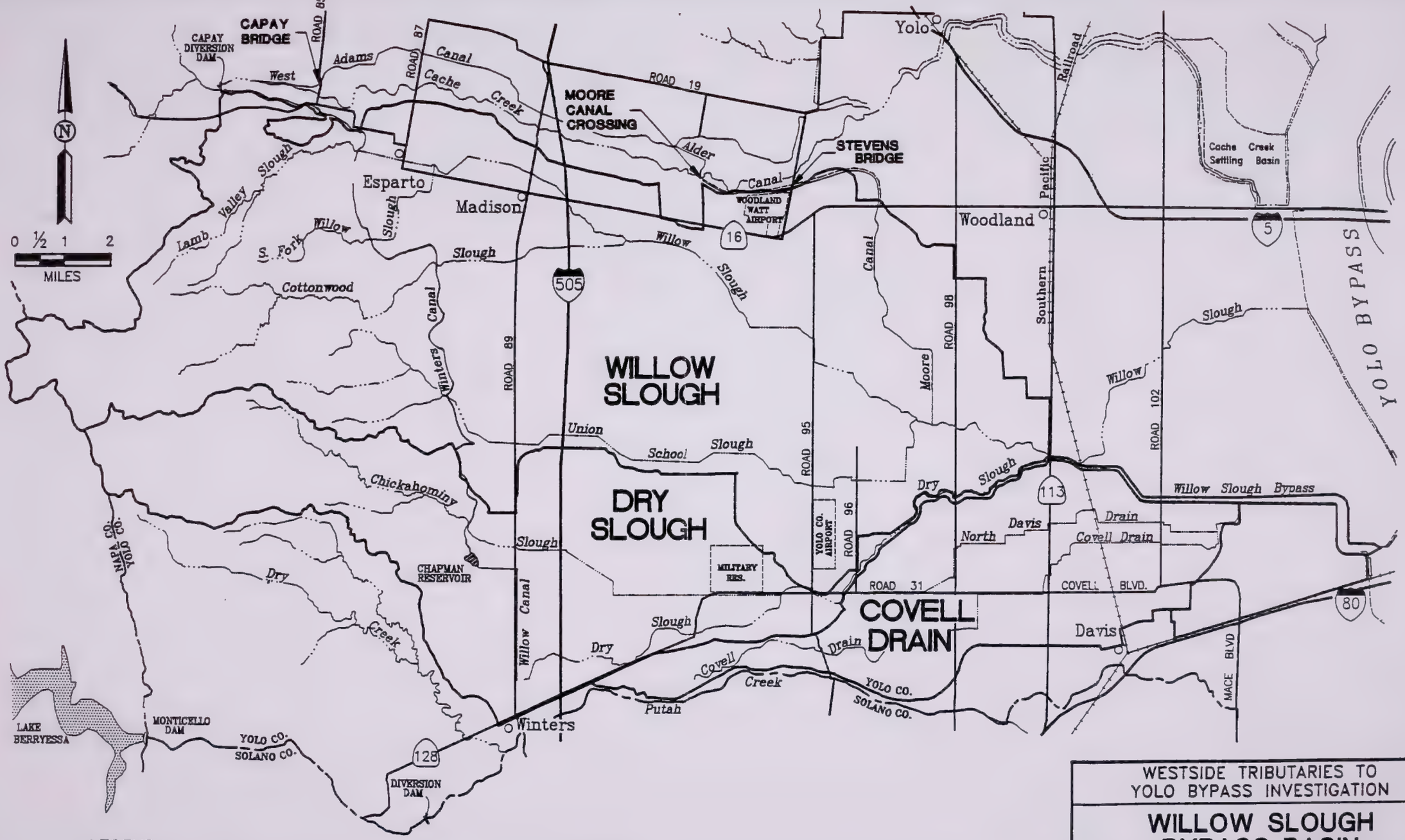
PRINCIPAL DRAINAGE

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

WILLOW SLOUGH BYPASS BASIN

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

ATE: MARCH, 1994 | PLATE: 2



LEGEND

PRINCIPAL WATERSHED BOUNDARY

PRINCIPAL DRAINAGE COURSE

SOURCES

1. U.S. GEOLOGICAL SURVEY, 7.5 MINUTE SERIES QUADRANGLE

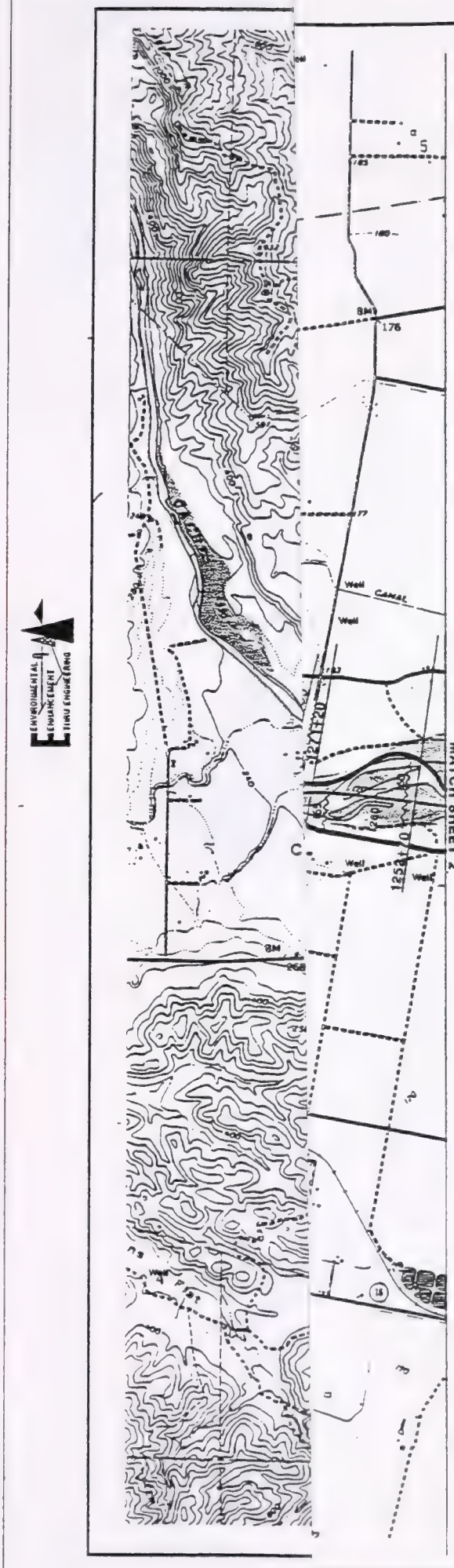
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

WILLOW SLOUGH BYPASS BASIN

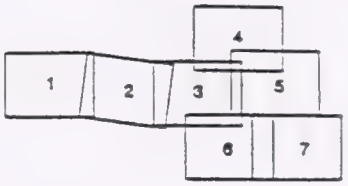
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

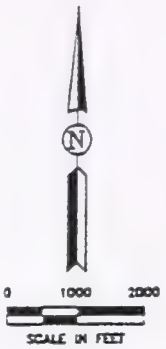
DATE: MARCH, 1994

PLATE: 2



SHEET INDEX





LEGEND

———	50-YEAR FLOOD LIMITS
——50——	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR.
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

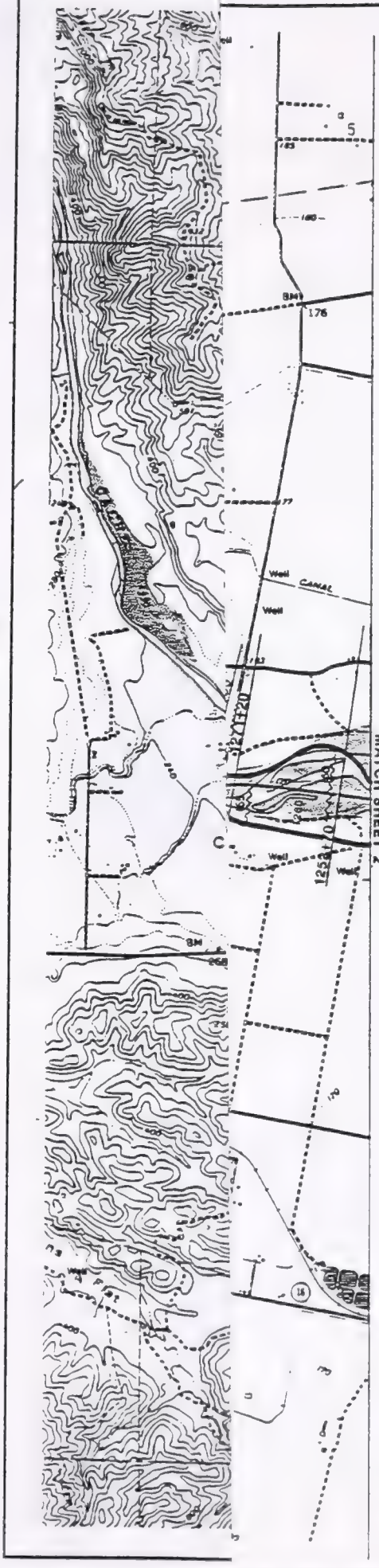
DEPARTMENT OF THE ARMY

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

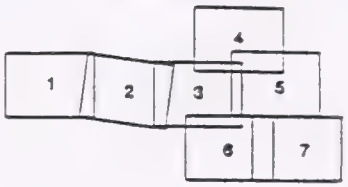
FLOODPLAINS CACHE CREEK

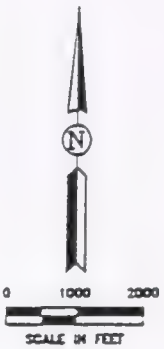
S.A.W.

PLATE 3



SHEET INDEX





LEGEND

———	50-YEAR FLOOD LIMITS
50	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE

ENVIRONMENTAL ENHANCEMENT FLOOD ENGINEERING

DEPARTMENT OF THE ARMY

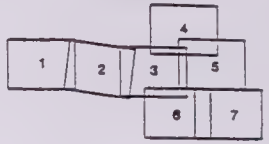
S.A.W.

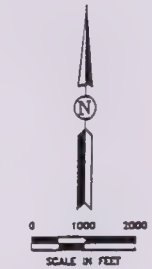
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

FLOODPLAINS CACHE CREEK

PLATE 3

SHEET INDEX





LEGEND

———	50-YEAR FLOOD LIMITS
50	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR.
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)

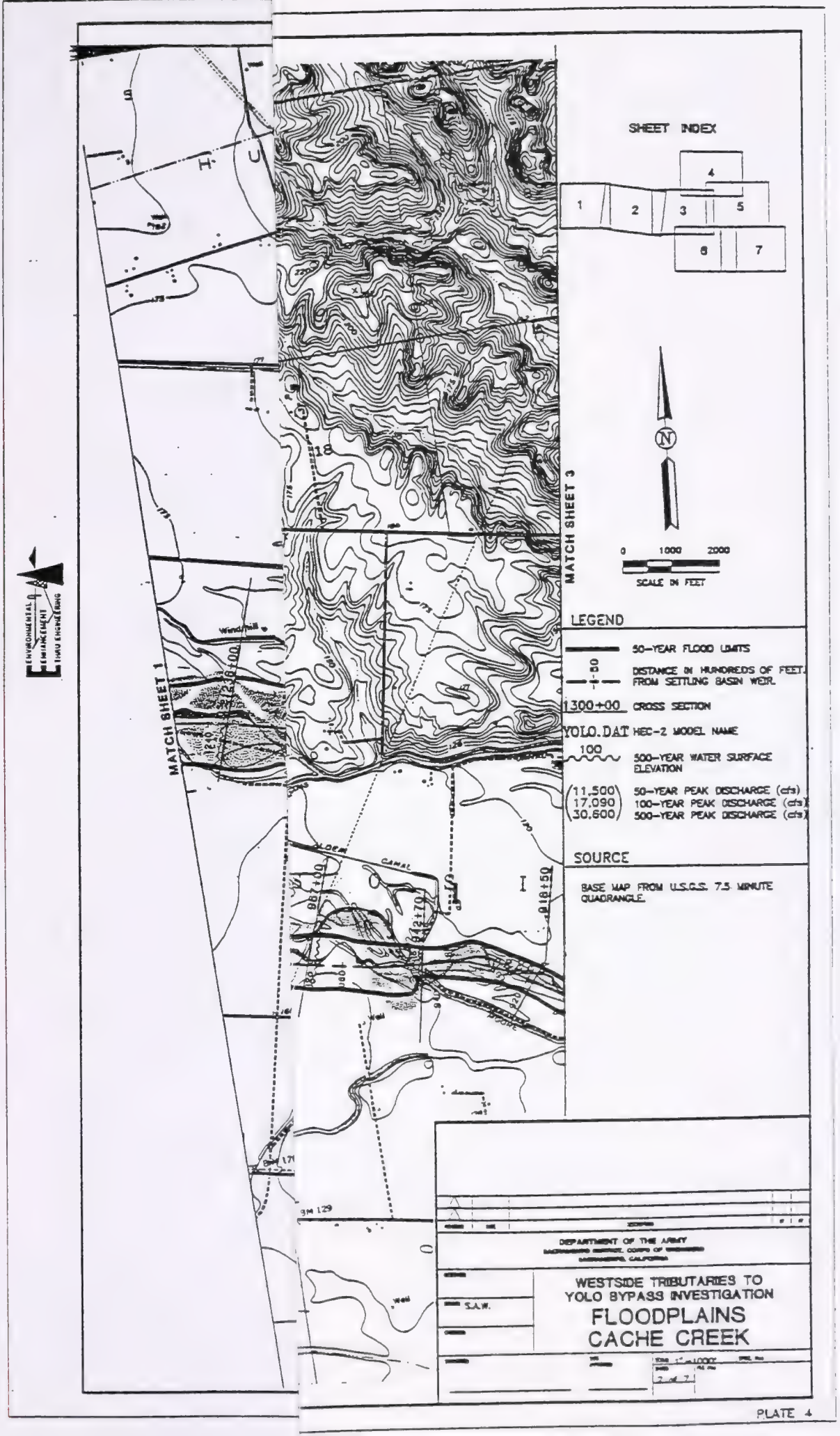
SOURCE

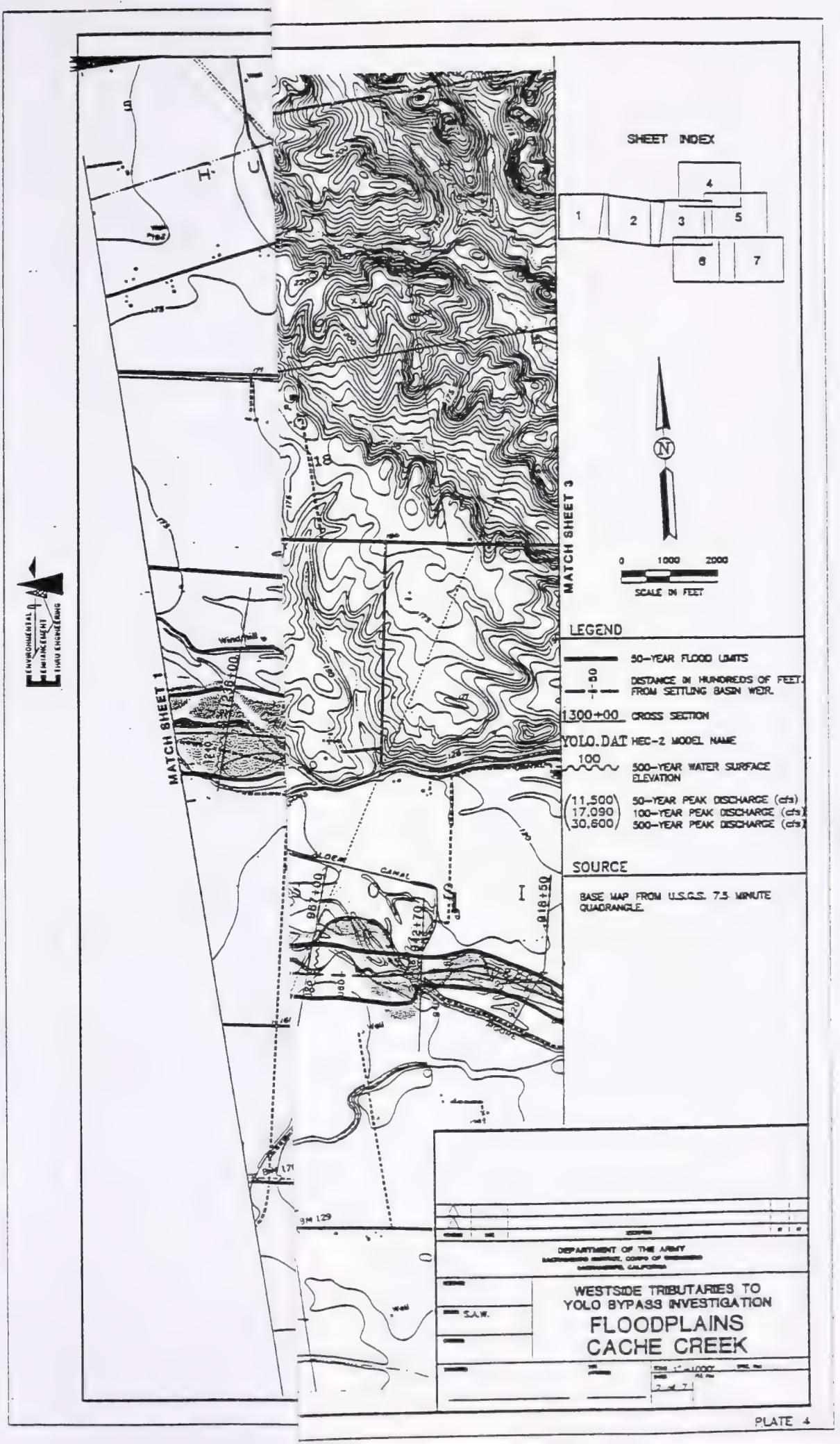
BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

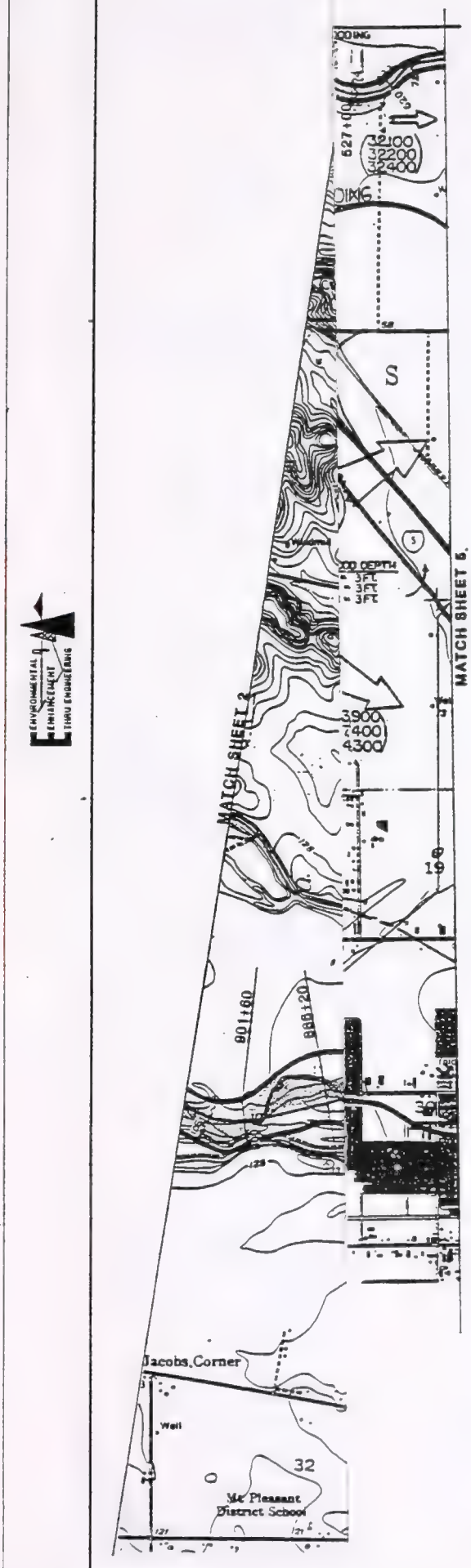
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION
FLOODPLAINS
CACHE CREEK

PLATE 3

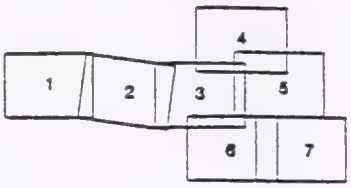

SHEET INDEX
4
1
2
3
5
6
7
N
0
1000
2000
SCALE IN FEET
MATCH SHEET 3
MATCH SHEET 1
LEGEND
50-YEAR FLOOD LIMITS
+50
DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR
1300+00
CROSS SECTION
YOLO.DAT
HEC-2 MODEL NAME
100
500-YEAR WATER SURFACE ELEVATION
11,500
17,090
30,600
50-YEAR PEAK DISCHARGE (cfs)
100-YEAR PEAK DISCHARGE (cfs)
500-YEAR PEAK DISCHARGE (cfs)
SOURCE
BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING
DEPARTMENT OF THE ARMY
S.A.W.
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION
FLOODPLAINS
CACHE CREEK
PLATE 4

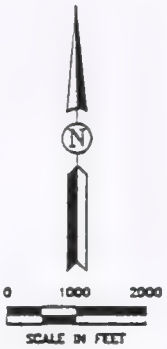

SHEET INDEX
1
2
3
4
5
6
7
MATCH SHEET 3
MATCH SHEET 1
0 1000 2000
SCALE IN FEET
LEGEND
50-YEAR FLOOD LIMITS
+50 DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR
1300+00 CROSS SECTION
YOLO.DAT HEC-2 MODEL NAME
100 500-YEAR WATER SURFACE ELEVATION
(11,500 50-YEAR PEAK DISCHARGE (cfs)
17,090 100-YEAR PEAK DISCHARGE (cfs)
30,600) 500-YEAR PEAK DISCHARGE (cfs)
SOURCE
BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.
ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING
DEPARTMENT OF THE ARMY
S.A.W.
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION
FLOODPLAINS
CACHE CREEK
PLATE 4

SHEET INDEX
1
2
3
4
5
6
7
MATCH SHEET 1
MATCH SHEET 3
0 1000 2000
SCALE IN FEET
LEGEND
50-YEAR FLOOD LIMITS
DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR.
1300+00 CROSS SECTION
YOLO.DAT HEC-2 MODEL NAME
100 500-YEAR WATER SURFACE ELEVATION
11,500 50-YEAR PEAK DISCHARGE (cfs)
17,090 100-YEAR PEAK DISCHARGE (cfs)
30,600 500-YEAR PEAK DISCHARGE (cfs)
SOURCE
BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.
CACHE3E.DAT
56700
63500
80900
DEPARTMENT OF THE ARMY
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION
FLOODPLAINS
CACHE CREEK
S.A.W.



SHEET INDEX





LEGEND

———	50-YEAR FLOOD LIMITS
50	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1)	FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

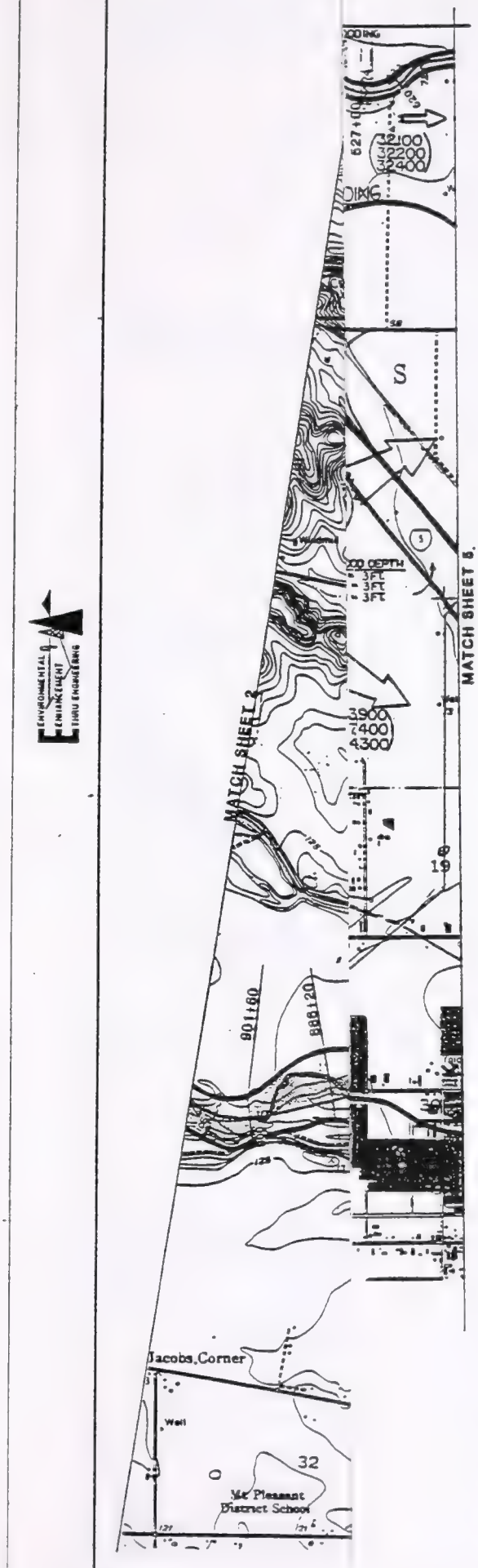
DEPARTMENT OF THE ARMY

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

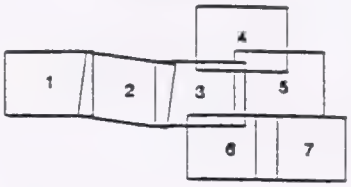
FLOODPLAINS CACHE CREEK

S.A.W.

PLATE 5



SHEET INDEX



LEGEND

———	50-YEAR FLOOD LIMITS
50	DISTANCE IN HUNDREDS OF FEET. FROM SETTLING BASIN WEIR.
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1)	FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE

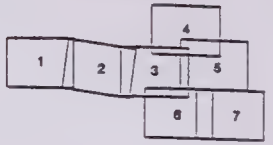
DEPARTMENT OF THE ARMY

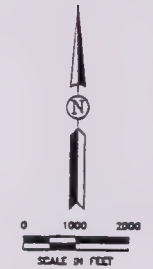
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

FLOODPLAINS CACHE CREEK

PLATE 5

SHEET INDEX





LEGEND

- 50-YEAR FLOOD LIMITS
- S — DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR.
- 1300+00 — CROSS SECTION
- WDLND.DAT — HEC-2 MODEL NAME
- 100 — 500-YEAR WATER SURFACE ELEVATION
- (11,500 / 17,090 / 30,600) — 50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
- (1) — FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

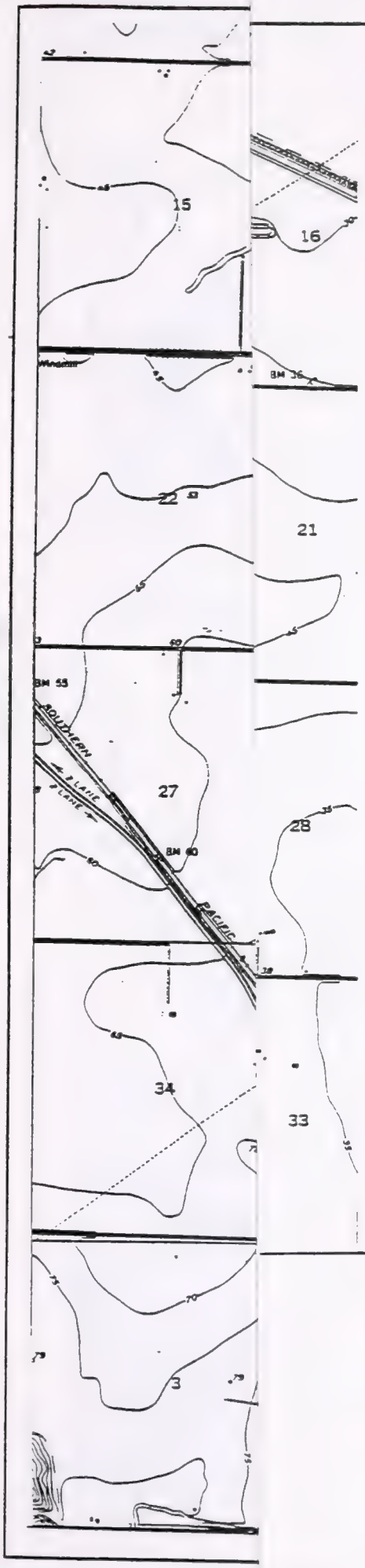
DEPARTMENT OF THE ARMY

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

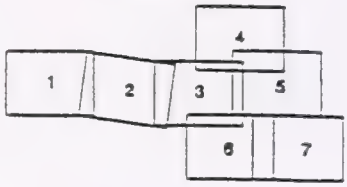
FLOODPLAINS
CACHE CREEK

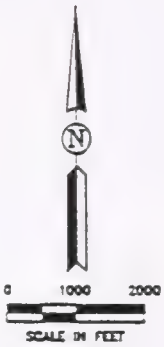
S.A.M.

3 of 7



SHEET INDEX





LEGEND

———	50-YEAR FLOOD LIMITS
50	DISTANCE IN HUNDREDS OF FEET. FROM SETTLING BASIN WEIR.
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1) ———	FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

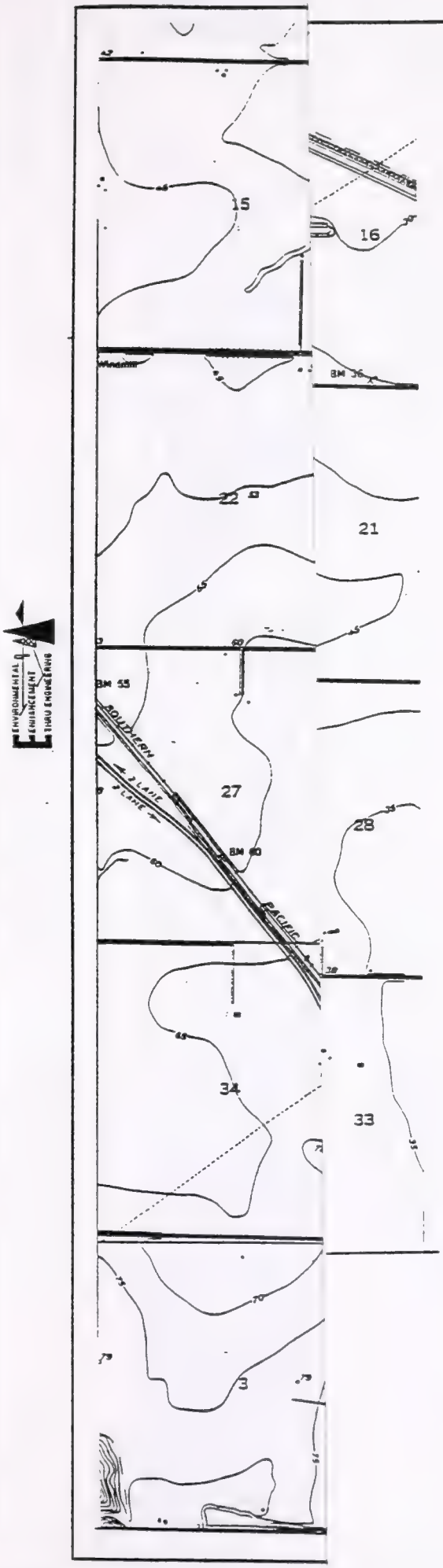
DEPARTMENT OF THE ARMY

S.A.W.

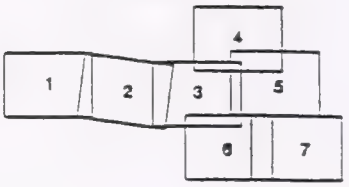
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

FLOODPLAINS CACHE CREEK

PLATE 6



SHEET INDEX



LEGEND

———	50-YEAR FLOOD LIMITS
0 / 5	DISTANCE IN HUNDREDS OF FEET. FROM SETTLING BASIN WEIR.
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1) ———	FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

DEPARTMENT OF THE ARMY

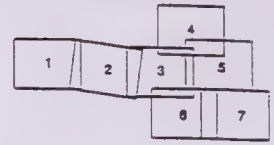
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

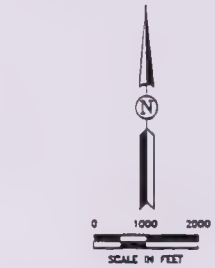
FLOODPLAINS CACHE CREEK

S.A.W.

PLATE 6

SHEET INDEX





LEGEND

———	50-YEAR FLOOD LIMITS
50	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR.
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1)	FLOODPLAIN CROSS SECTION

SOURCE

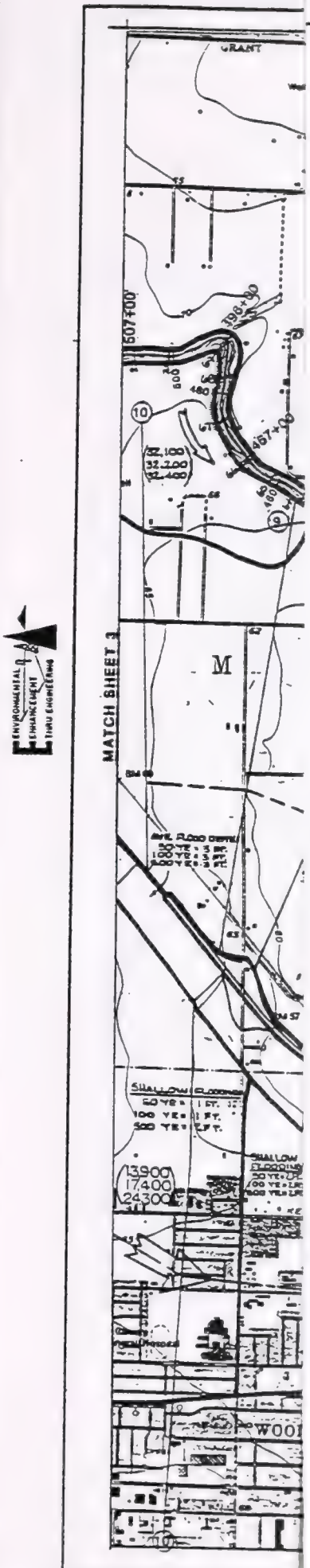
BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

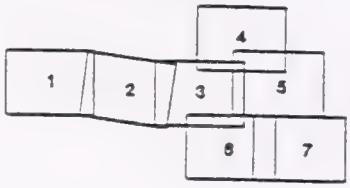
S.A.W.

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION
FLOODPLAINS
CACHE CREEK

PLATE 6



SHEET INDEX



LEGEND

———	50-YEAR FLOOD LIMITS
80	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1)	FLOODPLAIN CROSS SECTION

SOURCE

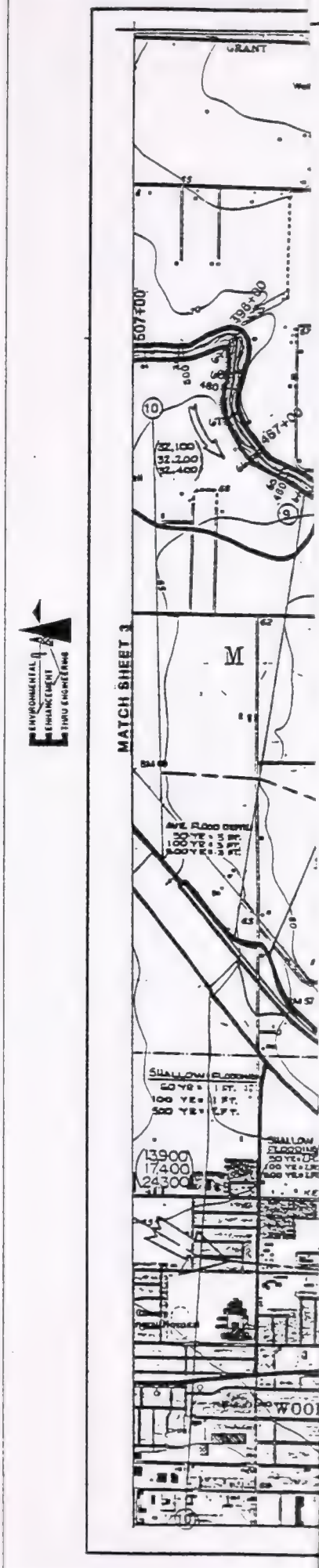
BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

DEPARTMENT OF THE ARMY

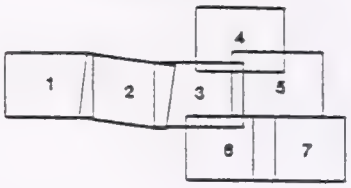
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

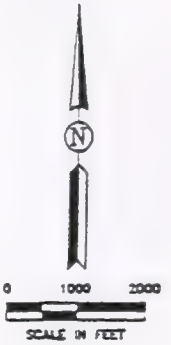
FLOODPLAINS CACHE CREEK

PLATE 7



SHEET INDEX





LEGEND

———	50-YEAR FLOOD LIMITS
50	DISTANCE IN HUNDREDS OF FEET. FROM SETTLING BASIN WEIR.
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1)	FLOODPLAIN CROSS SECTION

SOURCE

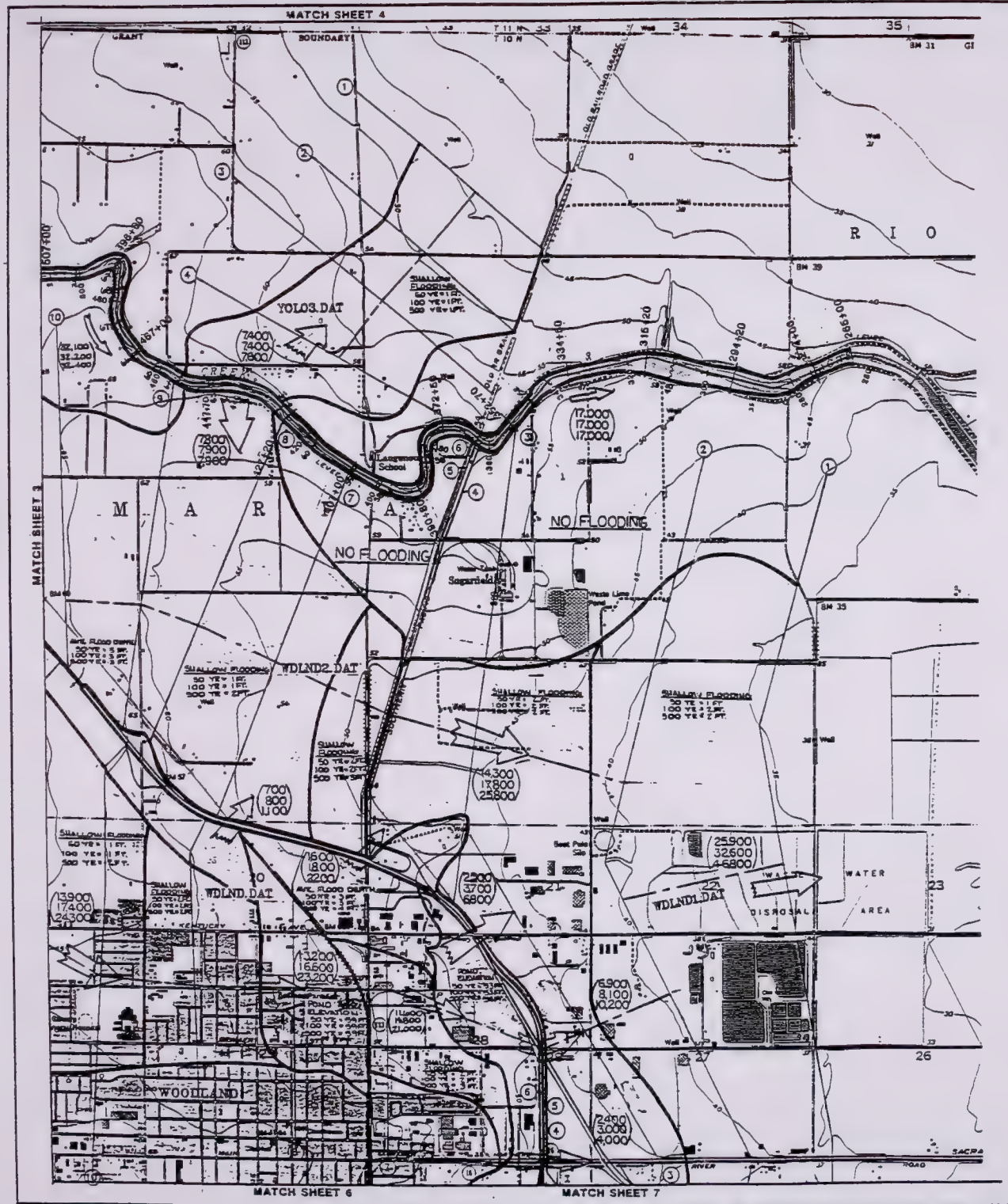
BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

DEPARTMENT OF THE ARMY

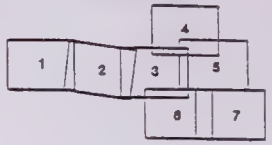
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

FLOODPLAINS CACHE CREEK

PLATE 7



SHEET INDEX



LEGEND

- 50-YEAR FLOOD LIMITS
- 50 — DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR.
- 1300+00 — CROSS SECTION
- WDLND.DAT — HEC-2 MODEL NAME
- 100 — 500-YEAR WATER SURFACE ELEVATION
- (11,500 / 17,090 / 30,500) — 50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
- (1) — FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

S.A.W.

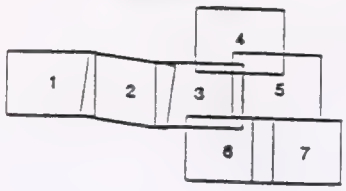
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

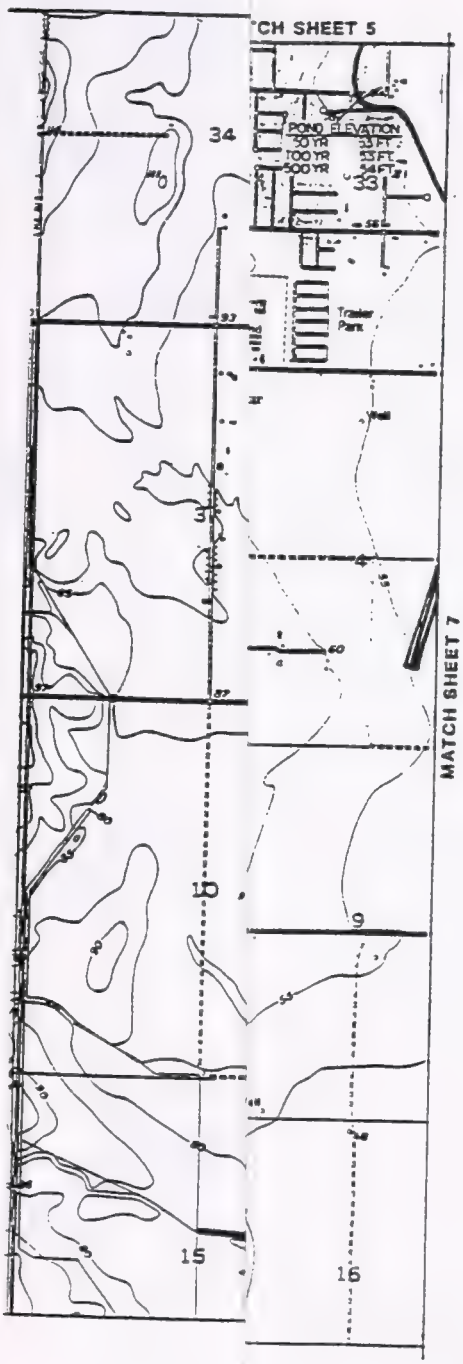
FLOODPLAINS CACHE CREEK

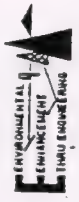
5 of 7

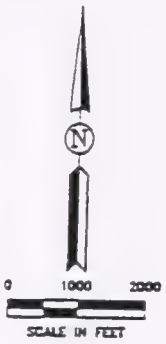
PLATE 7

SHEET INDEX









LEGEND

———	50-YEAR FLOOD LIMITS
—60—	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR.
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME.
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
①	FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DRAWN: S.A.W.

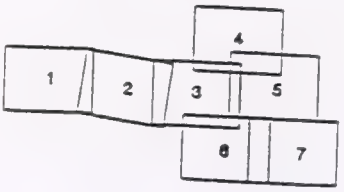
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

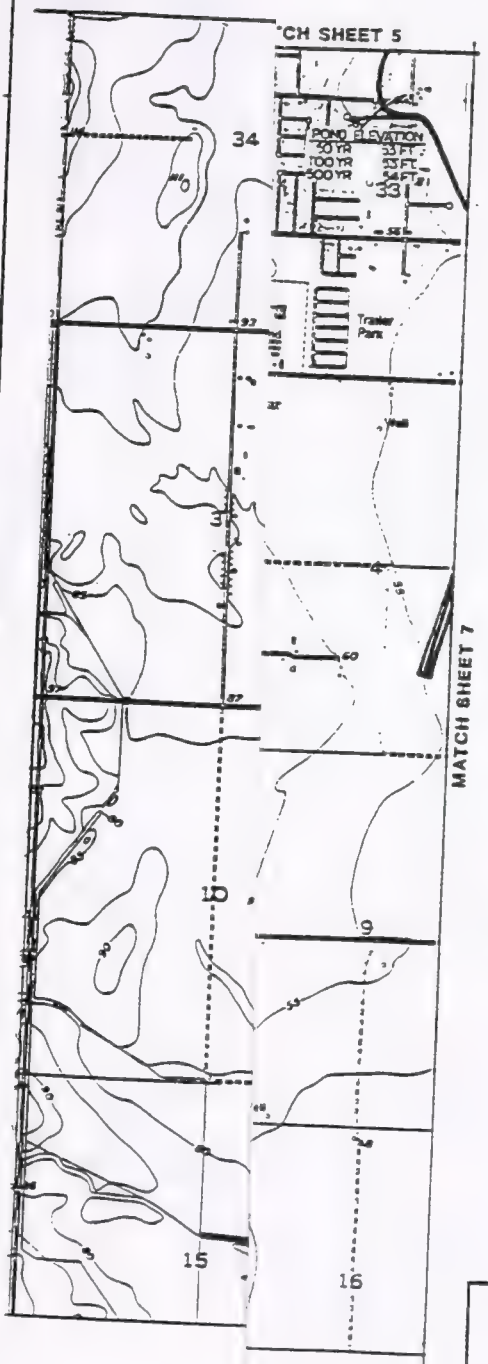
FLOODPLAINS CACHE CREEK

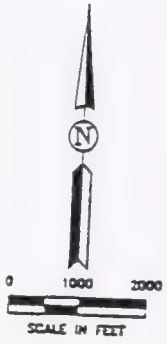
SCALE: 1" = 1000'

SHEET 6 of 7

SHEET INDEX







LEGEND

———	50-YEAR FLOOD LIMITS
——50——	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1) ———	FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE

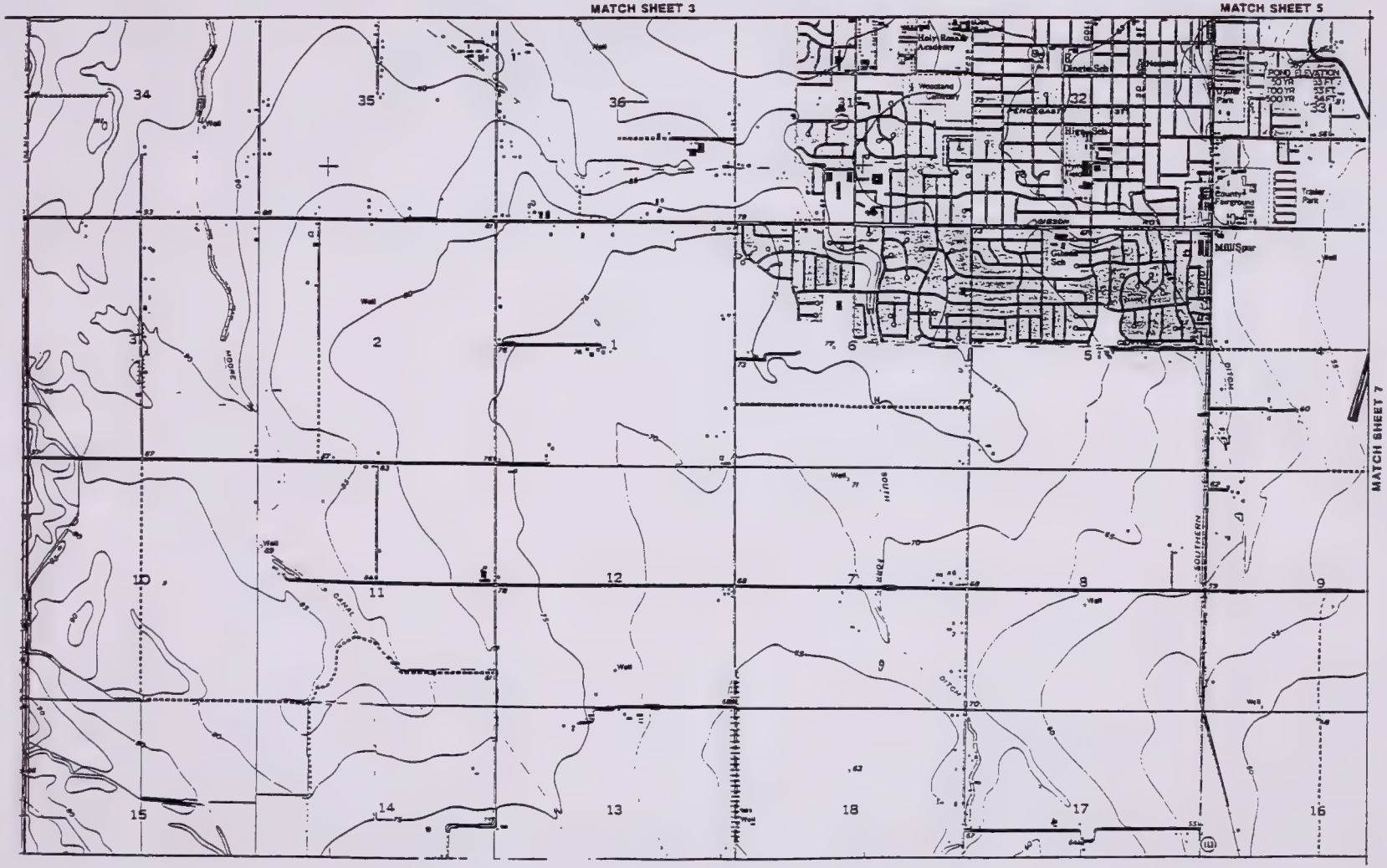
DEPARTMENT OF THE ARMY

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

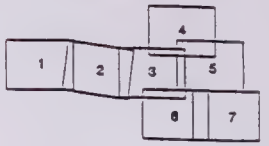
FLOODPLAINS CACHE CREEK

S.A.W.

PLATE 2



SHEET INDEX



LEGEND

———	50-YEAR FLOOD LIMITS
60	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1)	FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

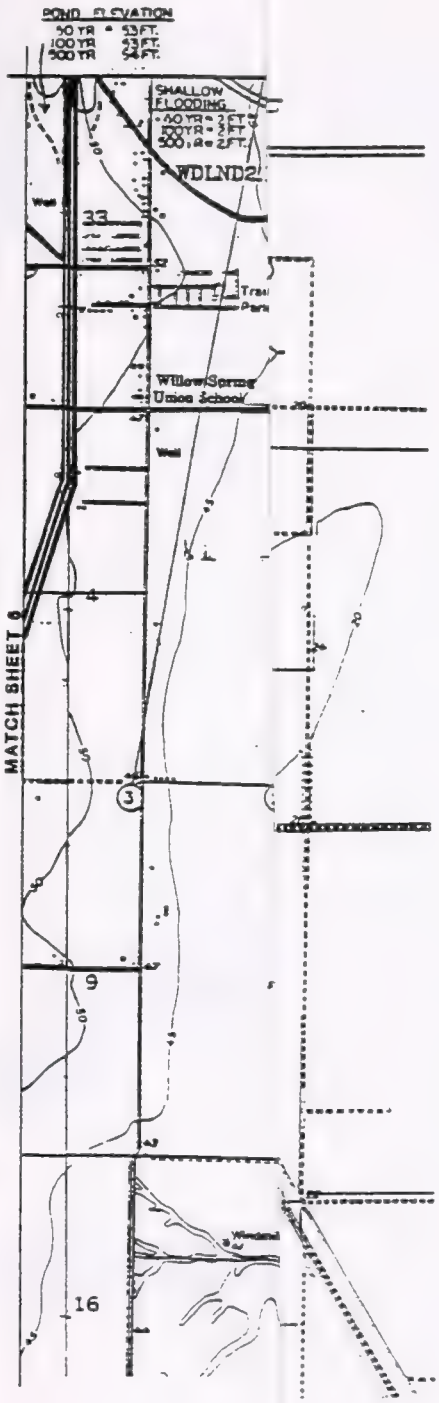
DEPARTMENT OF THE ARMY

S.A.W.

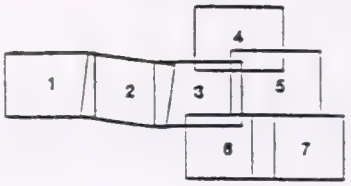
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

FLOODPLAINS
CACHE CREEK

8 of 7



SHEET INDEX



LEGEND

———	50-YEAR FLOOD LIMITS
50	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR.
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1)	FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

DEPARTMENT OF THE ARMY

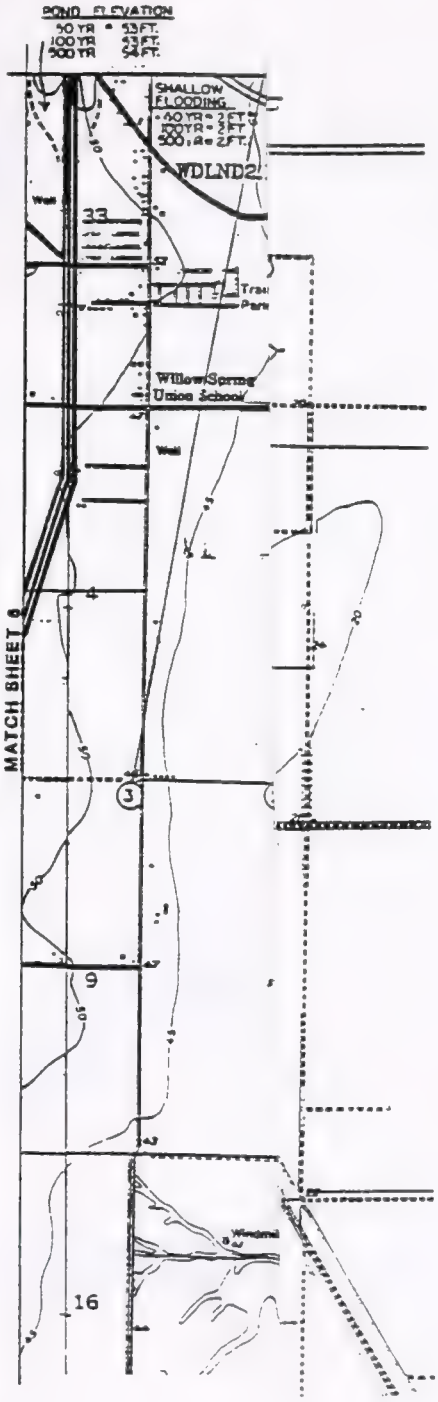
S.A.W.

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

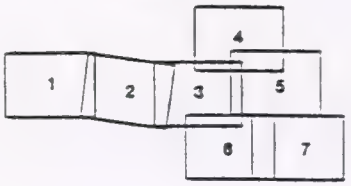
FLOODPLAINS CACHE CREEK

7 of 7

PLATE 9



SHEET INDEX



LEGEND

———	50-YEAR FLOOD LIMITS
—50—	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1)	FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

DEPARTMENT OF THE ARMY

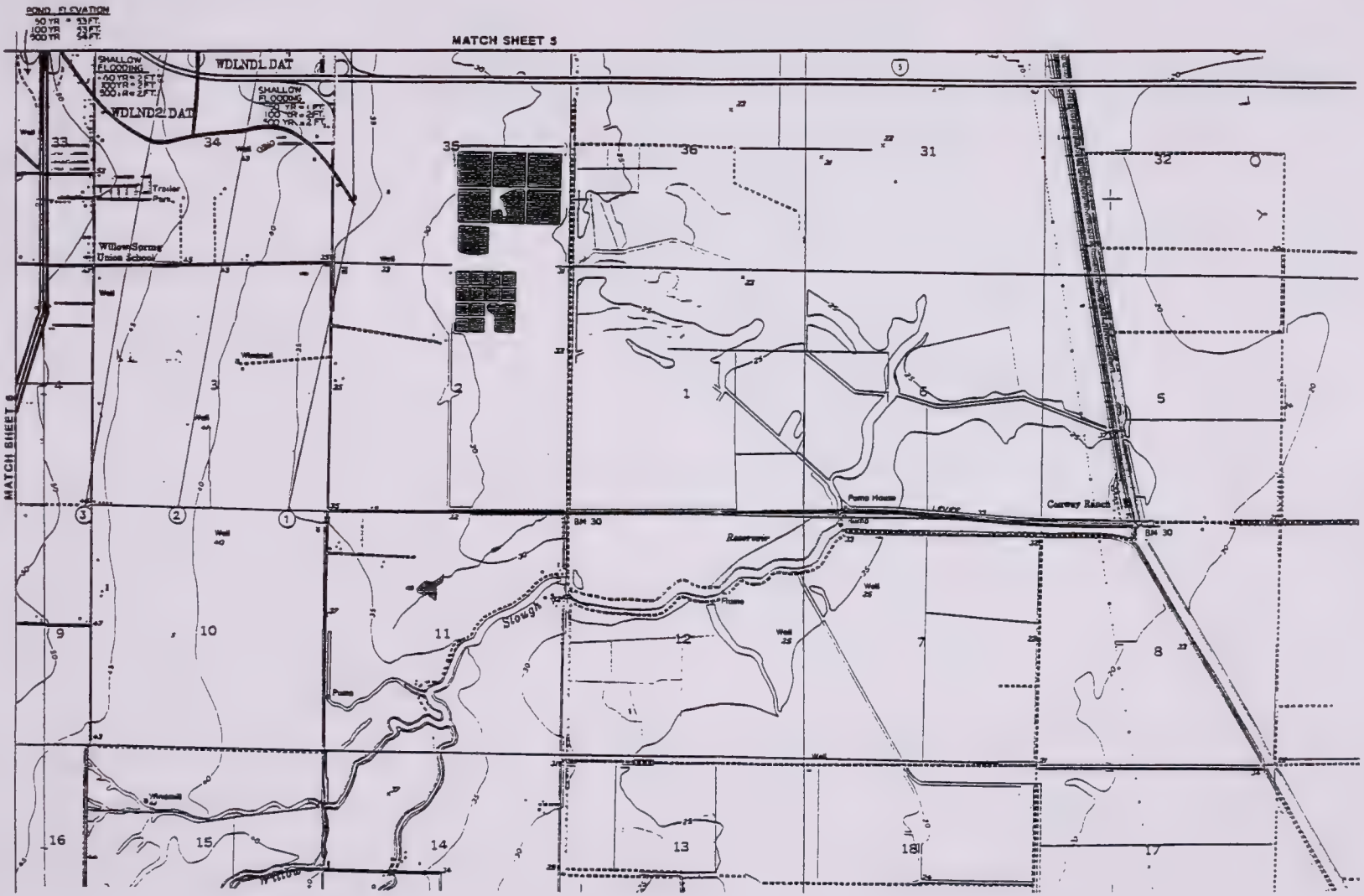
S.A.W.

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

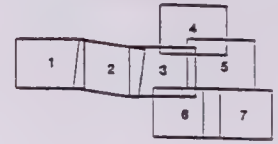
FLOODPLAINS CACHE CREEK

7 of 7

PLATE 9



SHEET INDEX



LEGEND

———	50-YEAR FLOOD LIMITS
50	DISTANCE IN HUNDREDS OF FEET FROM SETTLING BASIN WEIR
1300+00	CROSS SECTION
WDLND.DAT	HEC-2 MODEL NAME
100	500-YEAR WATER SURFACE ELEVATION
(11,500 / 17,090 / 30,600)	50-YEAR PEAK DISCHARGE (cfs) / 100-YEAR PEAK DISCHARGE (cfs) / 500-YEAR PEAK DISCHARGE (cfs)
(1) ———	FLOODPLAIN CROSS SECTION

SOURCE

BASE MAP FROM U.S.G.S. 7.5 MINUTE QUADRANGLE.

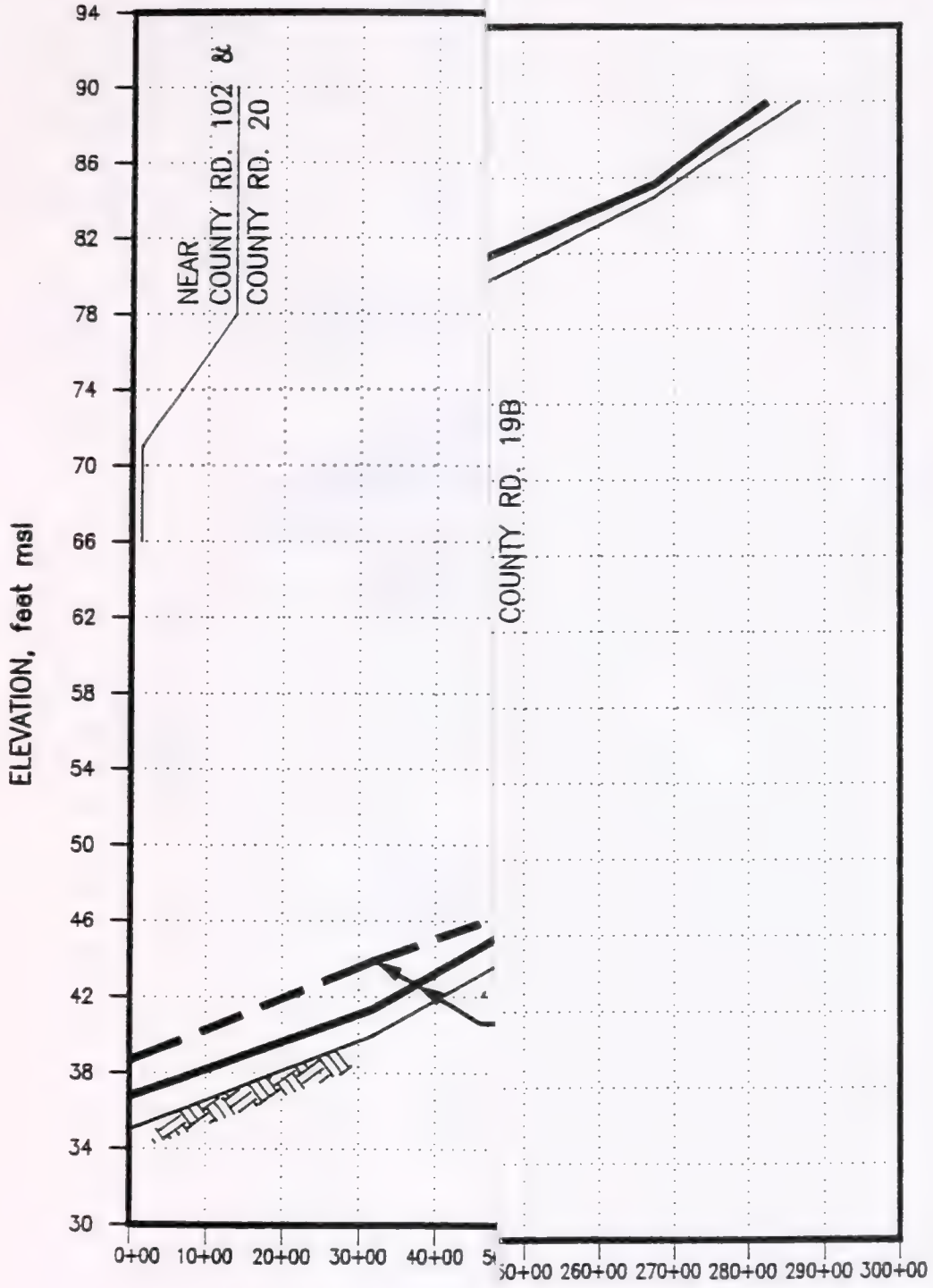
DEPARTMENT OF THE ARMY

S.A.W.

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

FLOODPLAINS CACHE CREEK

PLATE 9



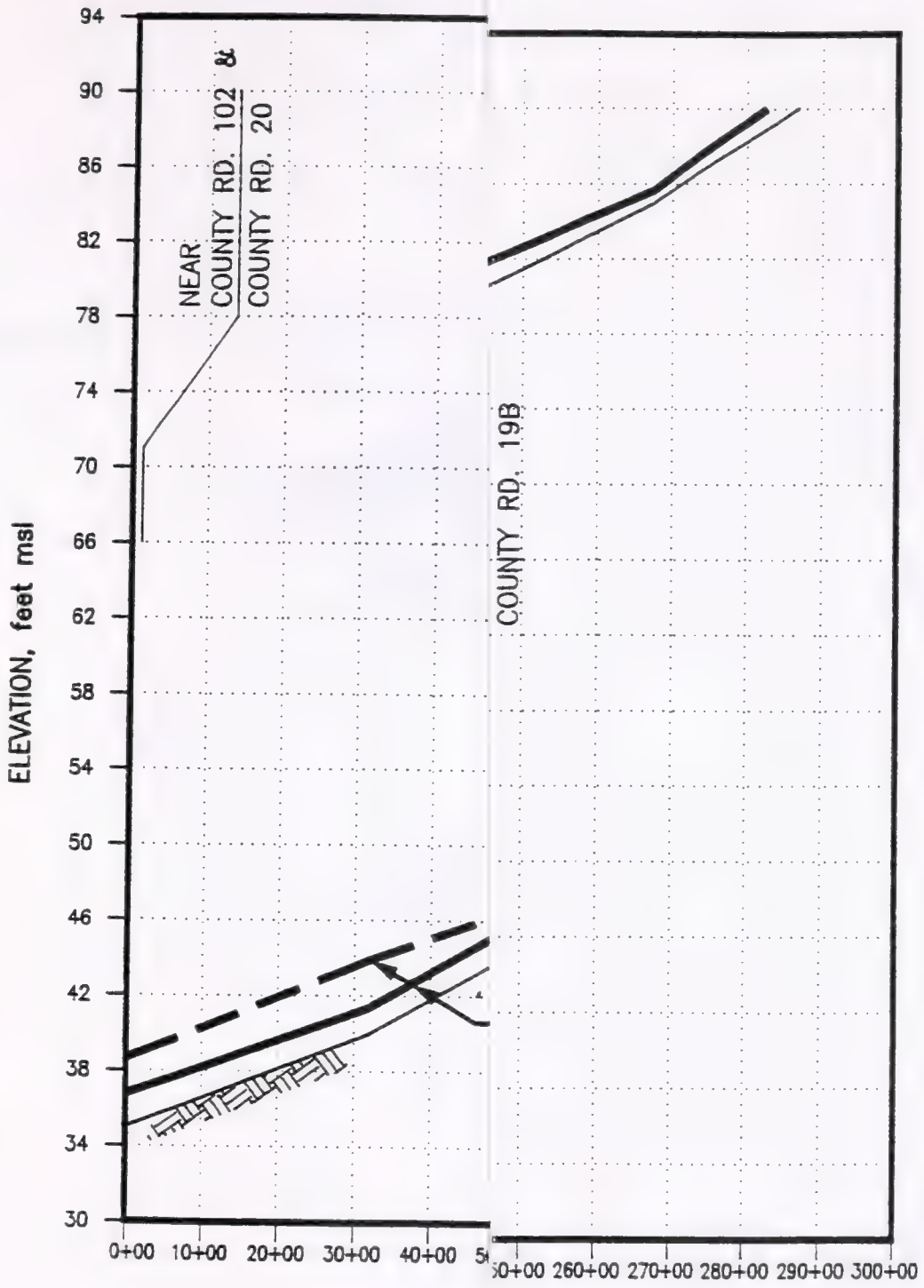
1/ Stationing is based up
See Plate 7, Sheet 5
of floodplain centerline
on the Woodland flood

WESTSIDE TRIBUTARIES TO
YOLO BYPASS INVESTIGATION

PROFILE - WOODLAND FLOODPLAIN

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

ATE: MARCH 1994 | PLATE: 10



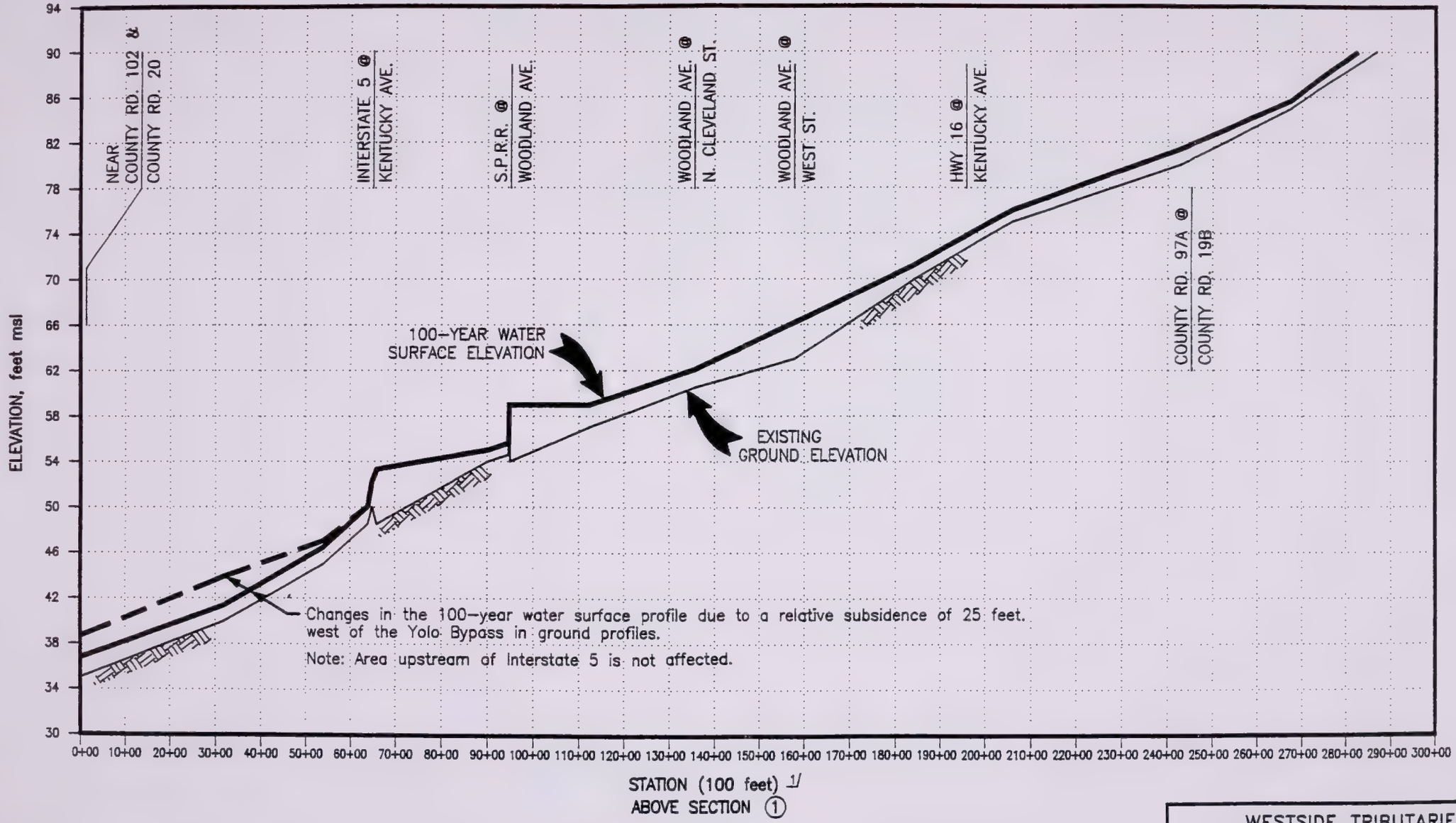
1/ Stationing is based up
See Plate 7, Sheet 5
of floodplain centerline
on the Woodland flood

WESTSIDE TRIBUTARIES TO
YOLO BYPASS INVESTIGATION

PROFILE - WOODLAND FLOODPLAIN

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

ATE: MARCH 1994 | PLATE: 10


ELEVATION, feet msl
94
90
86
82
78
74
70
66
62
58
54
50
46
42
38
34
30
NEAR COUNTY RD. 102 & COUNTY RD. 20
INTERSTATE 5 @ KENTUCKY AVE.
S.P.R.R. @ WOODLAND AVE.
WOODLAND AVE. @ N. CLEVELAND ST.
WOODLAND AVE. @ WEST ST.
HWY 16 @ KENTUCKY AVE.
COUNTY RD. 97A @ COUNTY RD. 19B
100-YEAR WATER SURFACE ELEVATION
EXISTING GROUND ELEVATION
Changes in the 100-year water surface profile due to a relative subsidence of 25 feet. west of the Yolo Bypass in ground profiles.
Note: Area upstream of Interstate 5 is not affected.
0+00 10+00 20+00 30+00 40+00 50+00 60+00 70+00 80+00 90+00 100+00 110+00 120+00 130+00 140+00 150+00 160+00 170+00 180+00 190+00 200+00 210+00 220+00 230+00 240+00 250+00 260+00 270+00 280+00 290+00 300+00
STATION (100 feet) 1/
ABOVE SECTION (1)

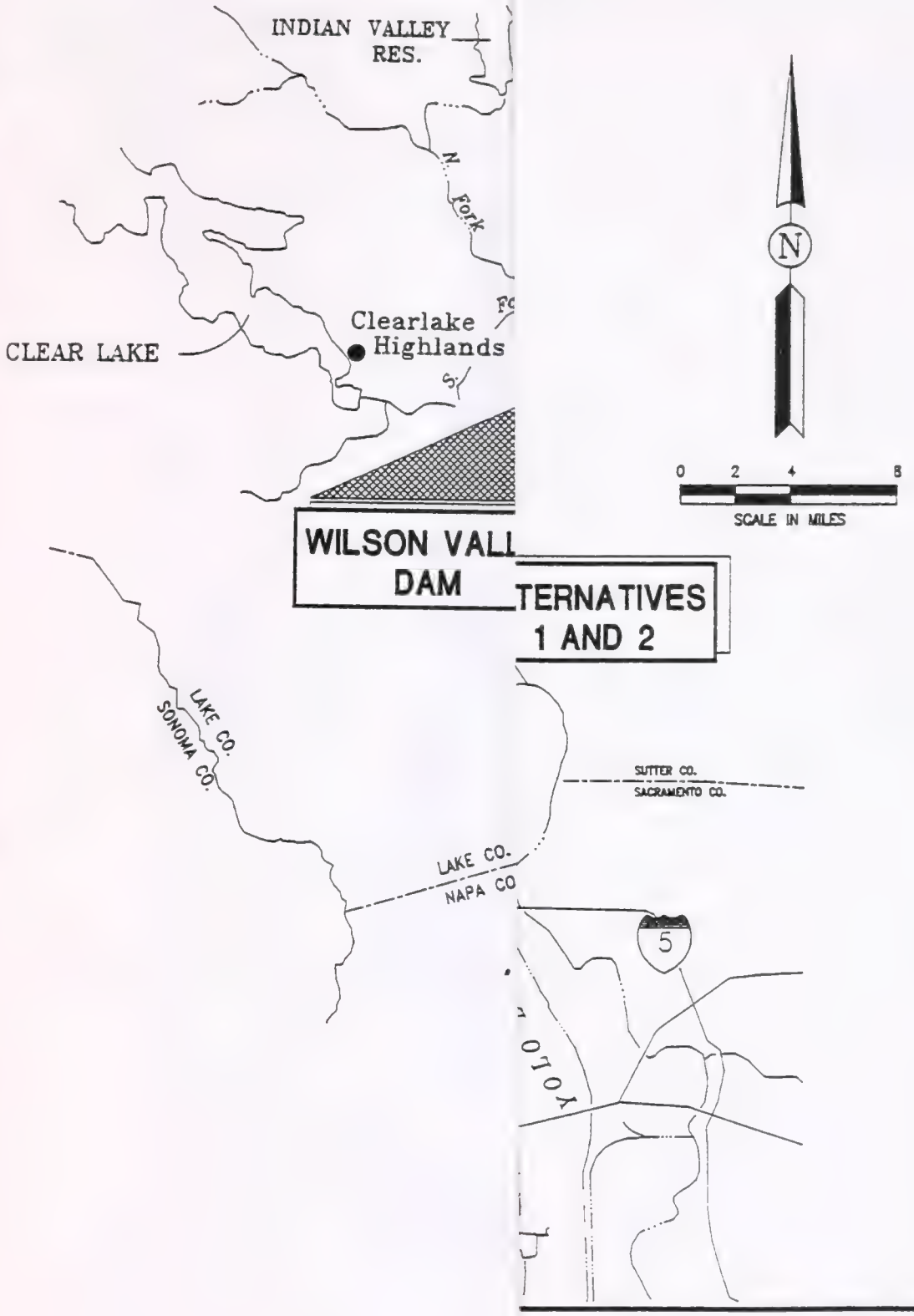
1/ Stationing is based upon centerline distances along Woodland floodplain. See Plate 7, Sheet 5 of 7, HEC-2 model WDLND.DAT for location of floodplain centerline. Station 0+00 corresponds to Section (1) on the Woodland floodplain.

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

PROFILE - WOODLAND FLOODPLAIN

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 PLATE: 10

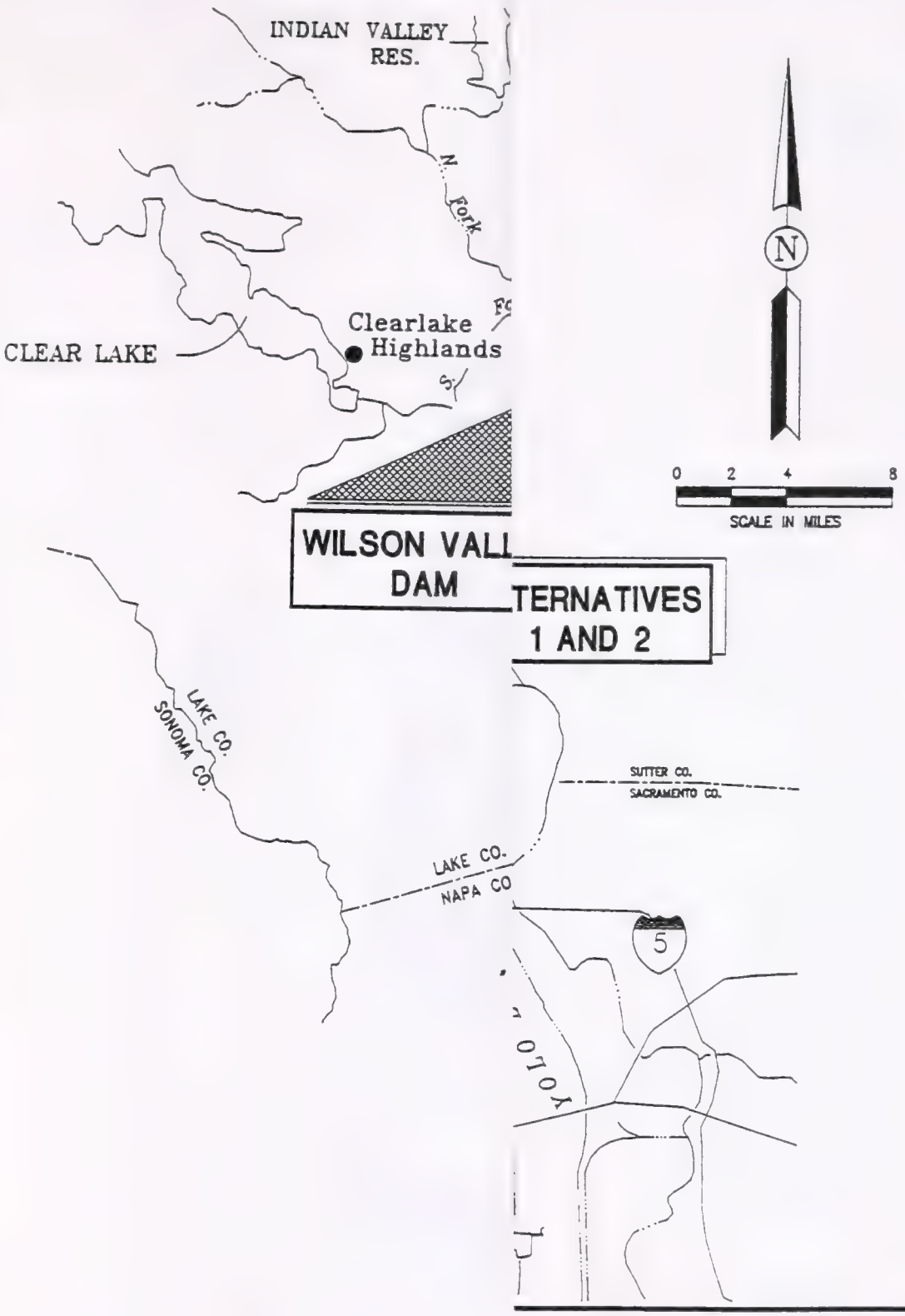


WESTSIDE TRIBUTARIES TO
YOLO BYPASS INVESTIGATION

PRELIMINARY ALTERNATIVES

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 11

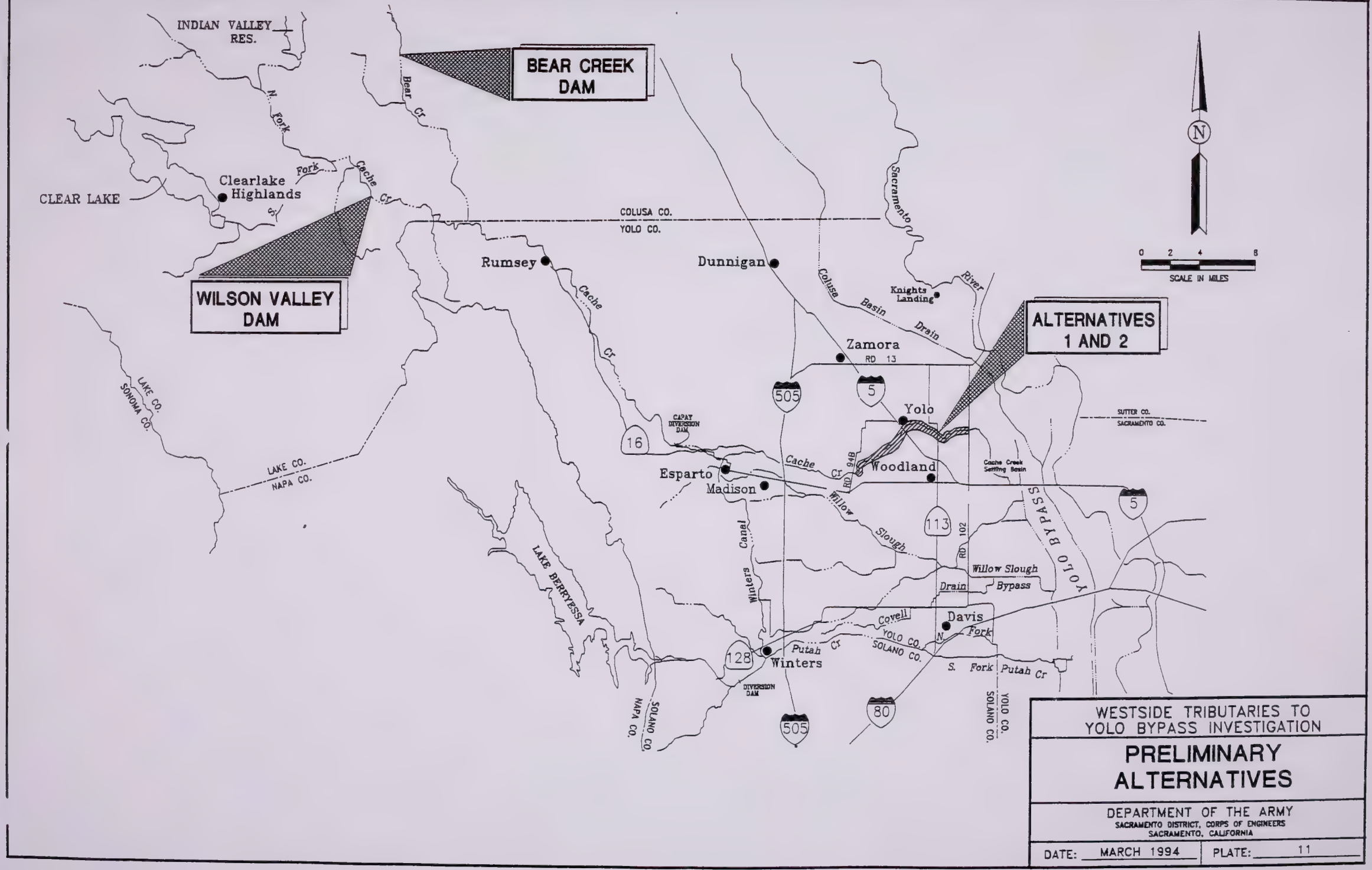


WESTSIDE TRIBUTARIES TO
YOLO BYPASS INVESTIGATION

PRELIMINARY ALTERNATIVES

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

TE: MARCH 1994 | PLATE: 11

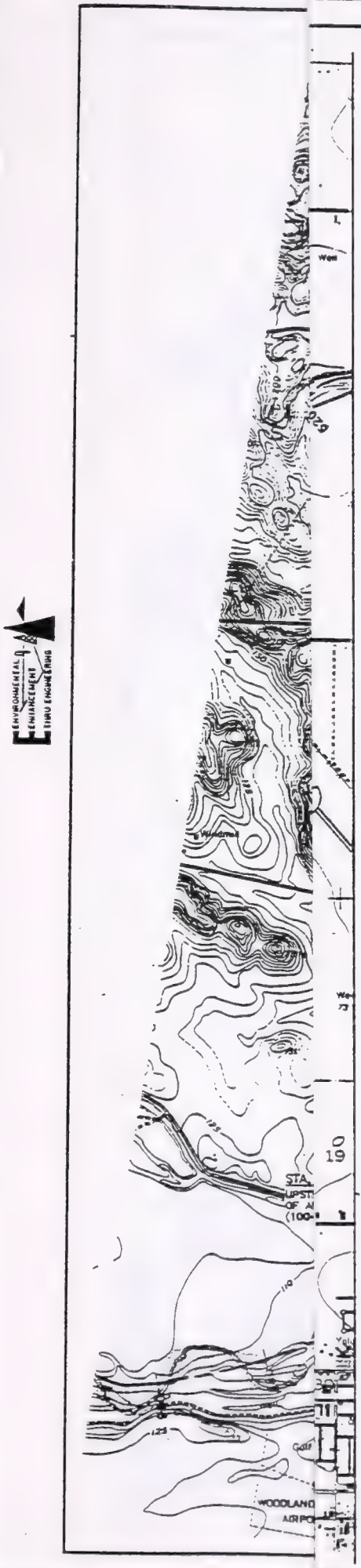


WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

PRELIMINARY ALTERNATIVES

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 11



SHEET INDEX

BRIDGE REPLACEMENTS		
CREEK	STATION	BRIDGE
CACHE	570+08	SPRR BRIDGE
CACHE	570+82	CACHEVILLE RD BRIDGE

LEGEND

- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' — 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') — 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

CACHE CREEK ALTERNATIVE 1

PLATE 12

SHEET INDEX

BRIDGE REPLACEMENTS		
CREEK	STATION	BRIDGE
CACHE	570+08	SPRR BRIDGE
CACHE	570+82	CACHEVILLE RD BRIDGE

LEGEND

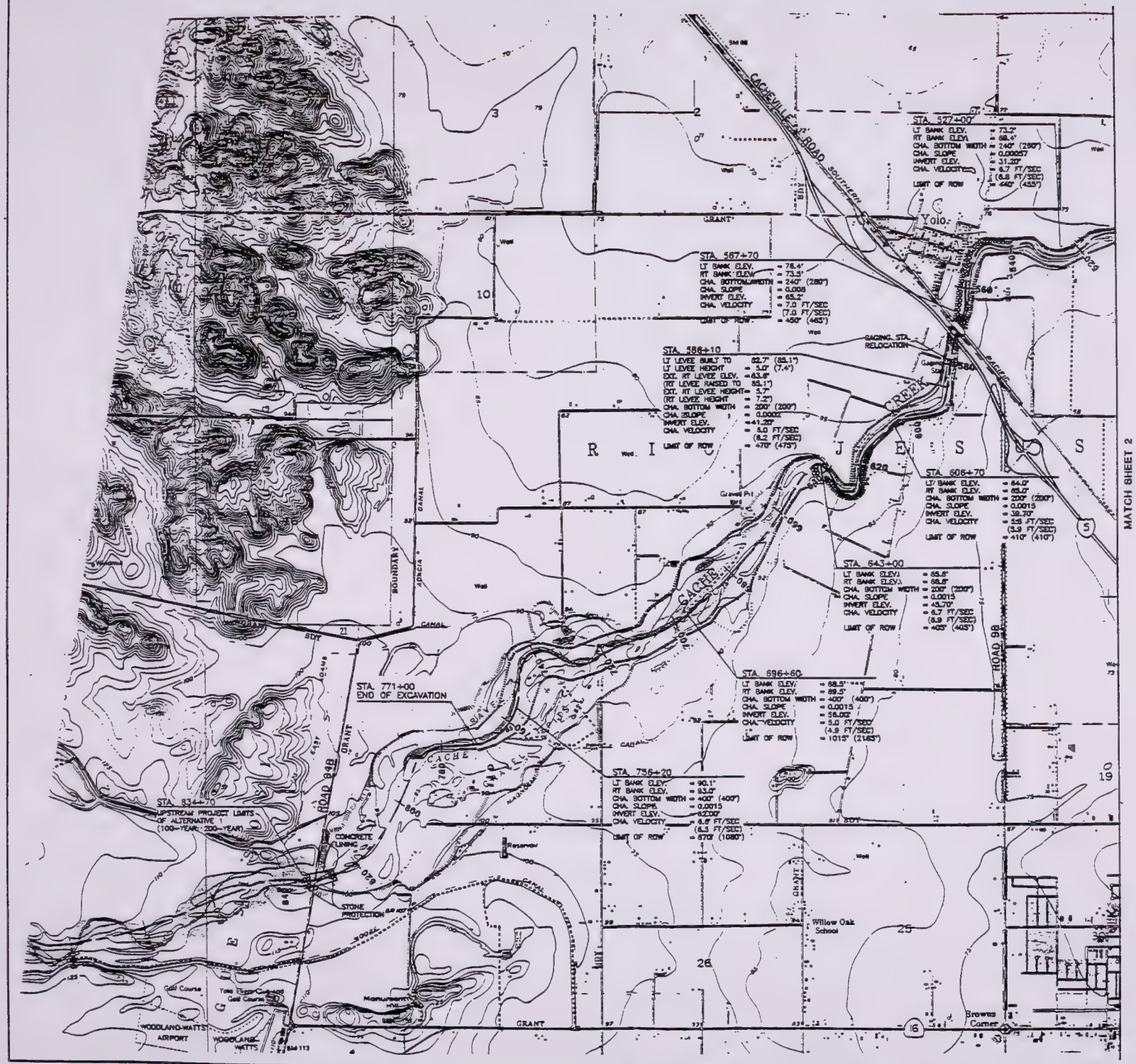
- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

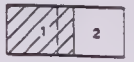
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

CACHE CREEK ALTERNATIVE 1

PLATE 12


CACHEVILLE ROAD
SOUTHERN PACIFIC
GRANT
BOUNDARY
CANAL
ROAD 94B
CACHE CREEK
GAGING STA. RELOCATION
STA. 527+00
LT BANK ELEV. = 73.2'
RT BANK ELEV. = 68.4'
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.000057
INVERT ELEV. = 31.20'
CHA. VELOCITY = 6.7 FT/SEC (6.8 FT/SEC)
LIMIT OF ROW = 440' (435')
STA. 567+70
LT BANK ELEV. = 78.4'
RT BANK ELEV. = 73.5'
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.0008
INVERT ELEV. = 65.2'
CHA. VELOCITY = 7.0 FT/SEC (7.0 FT/SEC)
LIMIT OF ROW = 450' (445')
STA. 586+10
LT LEVEE BUILT TO 82.7' (85.1')
LT LEVEE HEIGHT = 5.0' (7.4')
EXT. RT LEVEE ELEV. = 83.8'
(RT LEVEE RAISED TO 85.1')
EXT. RT LEVEE HEIGHT = 5.7'
(RT LEVEE HEIGHT = 7.2')
CHA. BOTTOM WIDTH = 200' (200')
CHA. SLOPE = 0.0002
INVERT ELEV. = 41.20'
CHA. VELOCITY = 8.0 FT/SEC (8.2 FT/SEC)
LIMIT OF ROW = 470' (475')
STA. 606+70
LT BANK ELEV. = 84.0'
RT BANK ELEV. = 85.0'
CHA. BOTTOM WIDTH = 200' (200')
CHA. SLOPE = 0.0015
INVERT ELEV. = 39.20'
CHA. VELOCITY = 6.5 FT/SEC (6.9 FT/SEC)
LIMIT OF ROW = 410' (410')
STA. 643+00
LT BANK ELEV. = 85.5'
RT BANK ELEV. = 86.5'
CHA. BOTTOM WIDTH = 200' (200')
CHA. SLOPE = 0.0015
INVERT ELEV. = 45.70'
CHA. VELOCITY = 6.7 FT/SEC (6.9 FT/SEC)
LIMIT OF ROW = 405' (405')
STA. 696+60
LT BANK ELEV. = 88.5'
RT BANK ELEV. = 89.5'
CHA. BOTTOM WIDTH = 400' (400')
CHA. SLOPE = 0.0015
INVERT ELEV. = 56.00'
CHA. VELOCITY = 5.0 FT/SEC (4.9 FT/SEC)
LIMIT OF ROW = 1015' (2145')
STA. 756+20
LT BANK ELEV. = 90.1'
RT BANK ELEV. = 93.0'
CHA. BOTTOM WIDTH = 400' (400')
CHA. SLOPE = 0.0015
INVERT ELEV. = 62.00'
CHA. VELOCITY = 6.6 FT/SEC (6.3 FT/SEC)
LIMIT OF ROW = 670' (1080')
STA. 771+00
END OF EXCAVATION
STA. 834+70
UPSTREAM PROJECT LIMITS OF ALTERNATIVE 1 (100-YEAR, 200-YEAR)
CONCRETE LINING
STONE PROTECTION
Willow Oak School
Browns Corner
WOODLAND-WATTS AIRPORT
Golf Course
Yolo
MATCH SHEET 2

SHEET INDEX



BRIDGE REPLACEMENTS		
CREEK	STATION	BRIDGE
CACHE	570+08	SPRR BRIDGE
CACHE	570+82	CACHEVILLE RD BRIDGE

LEGEND

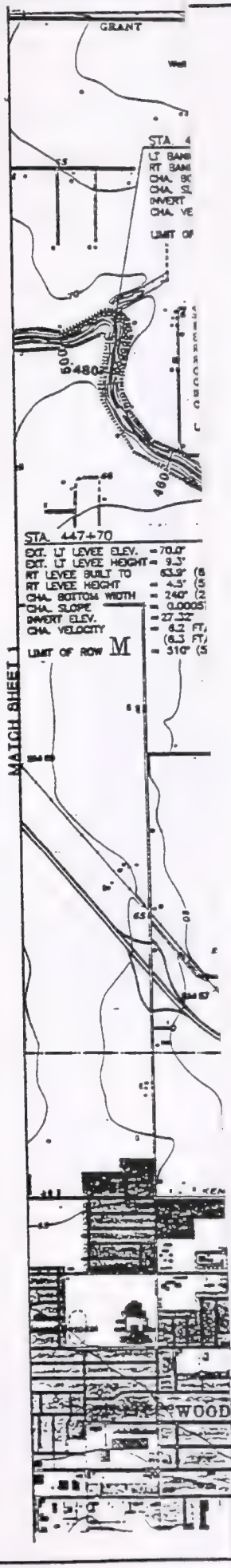
- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

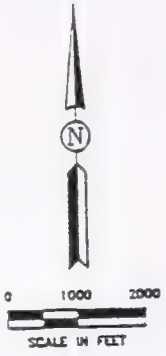
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

CACHE CREEK ALTERNATIVE 1

SAM



SHEET INDEX



ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

LEGEND

- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' — 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') — 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

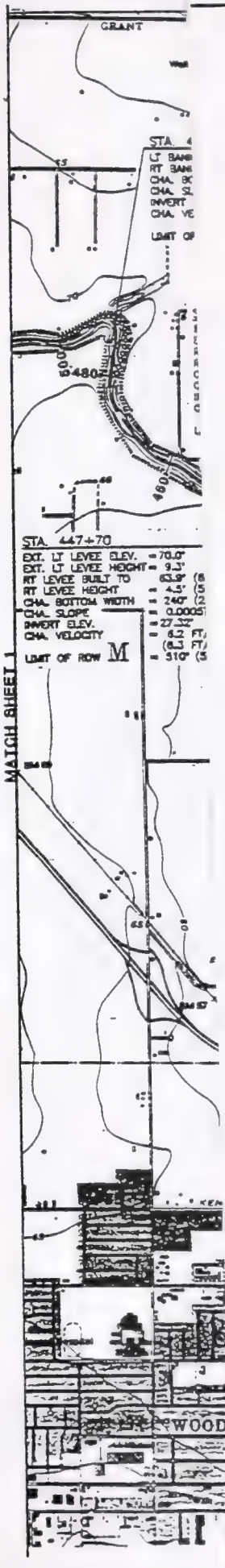
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

S.A.W.

CACHE CREEK ALTERNATIVE 1

2 of 2

PLATE



SHEET INDEX

LEGEND

- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' — 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') — 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

ENVIRONMENTAL ENHANCEMENT THRU ENGINEERING

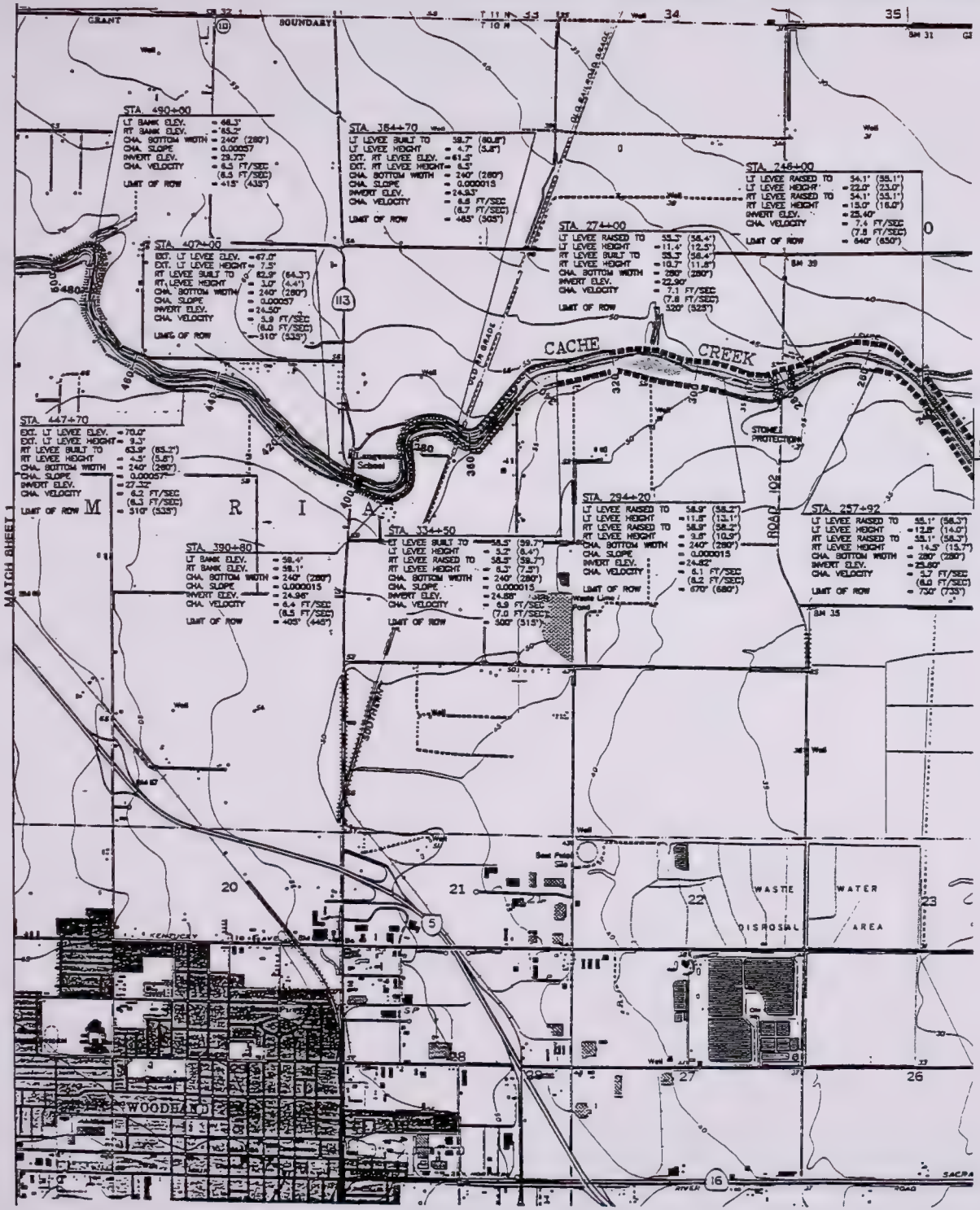
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

S.A.W.

CACHE CREEK ALTERNATIVE 1

PLATE 13


GRANT
BOUNDARY
CACHE CREEK
STA. 490+00
LT BANK ELEV. = 48.3'
RT BANK ELEV. = 65.2'
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.000057
INVERT ELEV. = 29.73'
CHA. VELOCITY = 6.5 FT/SEC (8.5 FT/SEC)
LIMIT OF ROW = 415' (435')
STA. 354+70
LT LEVEE BUILT TO 58.7' (60.2')
LT LEVEE HEIGHT = 4.7' (5.2')
EXT. RT LEVEE ELEV. = 61.5'
EXT. RT LEVEE HEIGHT = 6.5'
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.000015
INVERT ELEV. = 24.53'
CHA. VELOCITY = 6.6 FT/SEC (8.7 FT/SEC)
LIMIT OF ROW = 485' (505')
STA. 246+00
LT LEVEE RAISED TO 54.1' (55.1')
LT LEVEE HEIGHT = 22.0' (23.0')
RT LEVEE RAISED TO 54.1' (55.1')
RT LEVEE HEIGHT = 15.0' (16.0')
INVERT ELEV. = 23.40'
CHA. VELOCITY = 7.4 FT/SEC (7.8 FT/SEC)
LIMIT OF ROW = 640' (650')
STA. 274+00
LT LEVEE RAISED TO 55.1' (56.4')
LT LEVEE HEIGHT = 11.4' (12.5')
RT LEVEE BUILT TO 55.1' (56.4')
RT LEVEE HEIGHT = 10.7' (11.8')
CHA. BOTTOM WIDTH = 280' (280')
INVERT ELEV. = 22.90'
CHA. VELOCITY = 7.1 FT/SEC (7.8 FT/SEC)
LIMIT OF ROW = 320' (325')
STA. 407+00
EXT. LT LEVEE ELEV. = 67.0'
EXT. LT LEVEE HEIGHT = 7.5'
RT LEVEE BUILT TO 62.9' (64.3')
RT. LEVEE HEIGHT = 3.0' (4.4')
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.000057
INVERT ELEV. = 24.50'
CHA. VELOCITY = 5.9 FT/SEC (6.0 FT/SEC)
LIMIT OF ROW = 310' (335')
STA. 447+70
EXT. LT LEVEE ELEV. = 70.0'
EXT. LT LEVEE HEIGHT = 9.3'
RT LEVEE BUILT TO 63.9' (65.2')
RT LEVEE HEIGHT = 4.4' (5.8')
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.000057
INVERT ELEV. = 27.32'
CHA. VELOCITY = 6.2 FT/SEC (6.3 FT/SEC)
LIMIT OF ROW = 310' (335')
STA. 390+80
LT BANK ELEV. = 58.4'
RT BANK ELEV. = 58.1'
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.000015
INVERT ELEV. = 24.94'
CHA. VELOCITY = 6.4 FT/SEC (8.5 FT/SEC)
LIMIT OF ROW = 405' (445')
STA. 334+50
LT LEVEE BUILT TO 58.5' (59.7')
LT LEVEE HEIGHT = 3.2' (6.4')
RT LEVEE RAISED TO 58.5' (59.7')
RT LEVEE HEIGHT = 6.3' (7.5')
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.000015
INVERT ELEV. = 24.88'
CHA. VELOCITY = 6.9 FT/SEC (7.0 FT/SEC)
LIMIT OF ROW = 500' (515')
STA. 294+20
LT LEVEE RAISED TO 58.9' (58.2')
LT LEVEE HEIGHT = 11.8' (13.1')
RT LEVEE RAISED TO 58.9' (58.2')
RT LEVEE HEIGHT = 9.8' (10.9')
CHA. BOTTOM WIDTH = 240' (280')
CHA. SLOPE = 0.000015
INVERT ELEV. = 24.62'
CHA. VELOCITY = 6.1 FT/SEC (6.2 FT/SEC)
LIMIT OF ROW = 670' (680')
STA. 257+92
LT LEVEE RAISED TO 55.1' (56.3')
LT LEVEE HEIGHT = 12.8' (14.0')
RT LEVEE RAISED TO 55.1' (56.3')
RT LEVEE HEIGHT = 14.5' (15.7')
CHA. BOTTOM WIDTH = 280' (280')
INVERT ELEV. = 23.60'
CHA. VELOCITY = 5.7 FT/SEC (6.0 FT/SEC)
LIMIT OF ROW = 730' (735')
BEGIN CACHE CREEK SETTLING BASIN
STONE PROTECTION
MATCH SHEET
WASTE WATER DISPOSAL AREA
WOODLAND
SACRAMENTO RIVER
ROAD 102
SCALE IN FEET
0 1000 2000

SHEET INDEX

LEGEND

- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' — 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') — 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

CACHE CREEK ALTERNATIVE 1

S.A.W.

2 of 2

PLATE 13

SHEET INDEX

BRIDGE REPLACEMENTS		
CREEK	STATION	BRIDGE
CACHE	570+08	SPRR BRIDGE
CACHE	570+82	CACHEVILLE RD BRIDGE

LEGEND

- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' — 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') — 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

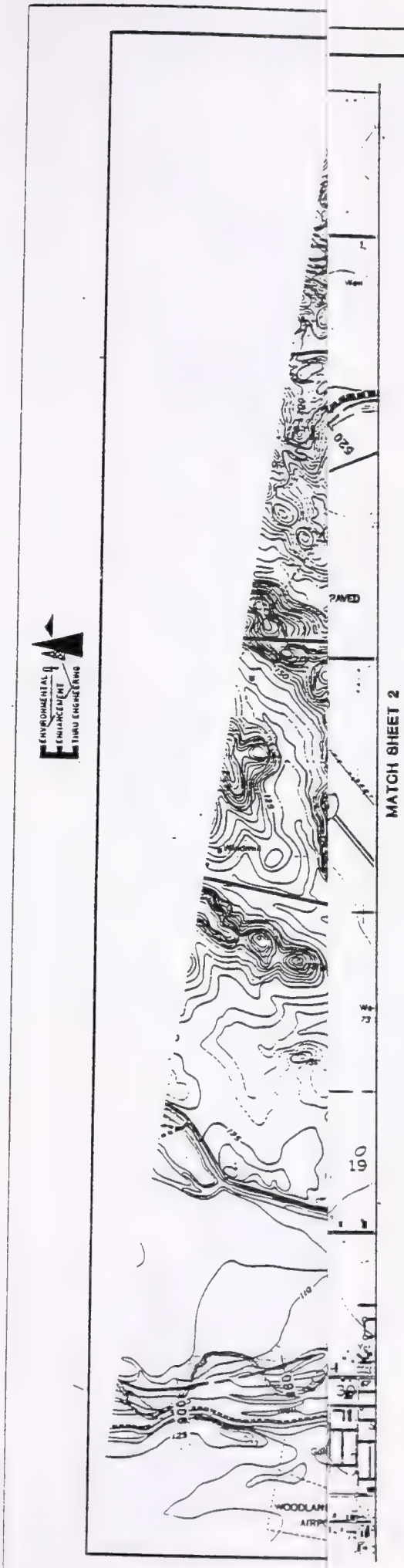
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

S.A.W.

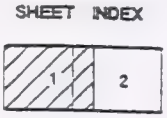
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

CACHE CREEK ALTERNATIVE 2

PLATE 14



SHEET INDEX



BRIDGE REPLACEMENTS		
CREEK	STATION	BRIDGE
CACHE	570+08	SPRR BRIDGE
CACHE	570+82	CACHEVILLE RD BRIDGE

LEGEND

- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' — 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') — 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

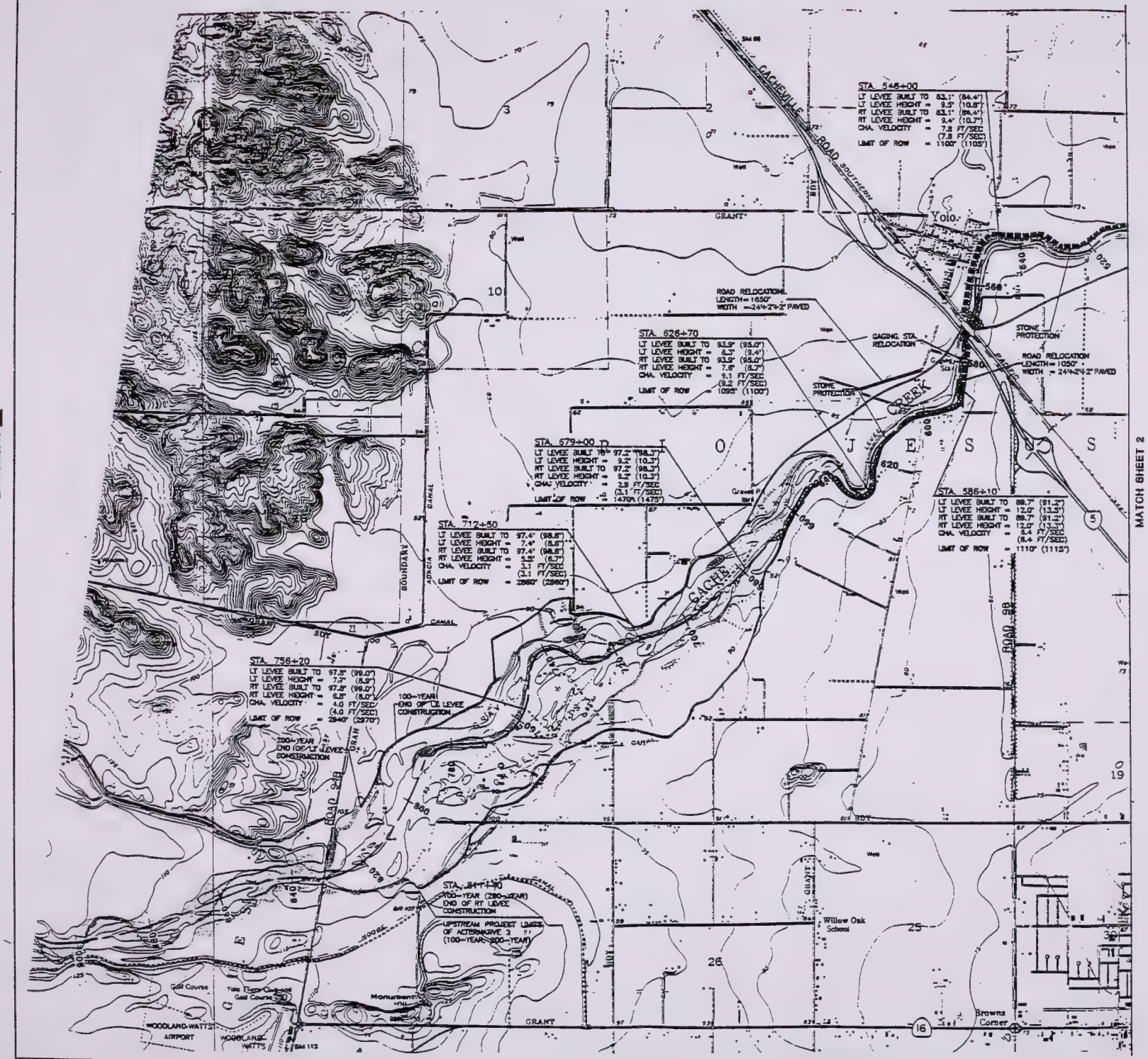
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

S.A.W.

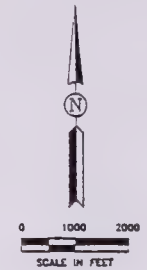
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

CACHE CREEK ALTERNATIVE 2

PLATE 14


CACHEVILLE ROAD SOUTHERN
STA. 546+00
LT LEVEE BUILT TO 83.1' (84.4')
LT LEVEE HEIGHT = 9.5' (10.8')
RT LEVEE BUILT TO 83.1' (84.4')
RT LEVEE HEIGHT = 9.4' (10.7')
CHA. VELOCITY = 7.8 FT/SEC (7.8 FT/SEC)
LIMIT OF ROW = 1100' (1105')
ROAD RELOCATIONS
LENGTH = 1650'
WIDTH = 24'+2'+2' PAVED
STA. 626+70
LT LEVEE BUILT TO 93.9' (95.0')
LT LEVEE HEIGHT = 8.3' (9.4')
RT LEVEE BUILT TO 93.9' (95.0')
RT LEVEE HEIGHT = 7.8' (8.7')
CHA. VELOCITY = 9.1 FT/SEC (9.2 FT/SEC)
LIMIT OF ROW = 1095' (1100')
GAGING STA. RELOCATION
STONE PROTECTION
ROAD RELOCATION
LENGTH = 1050'
WIDTH = 24'+2'+2' PAVED
STA. 679+00
LT LEVEE BUILT TO 97.2' (98.3')
LT LEVEE HEIGHT = 9.2' (10.3')
RT LEVEE BUILT TO 97.2' (98.3')
RT LEVEE HEIGHT = 9.2' (10.3')
CHA. VELOCITY = 2.9 FT/SEC (3.1 FT/SEC)
LIMIT OF ROW = 1470' (1475')
STA. 712+50
LT LEVEE BUILT TO 97.4' (98.5')
LT LEVEE HEIGHT = 7.4' (8.5')
RT LEVEE BUILT TO 97.4' (98.5')
RT LEVEE HEIGHT = 6.5' (7.6')
CHA. VELOCITY = 3.1 FT/SEC (3.1 FT/SEC)
LIMIT OF ROW = 2860' (2860')
STA. 586+10
LT LEVEE BUILT TO 89.7' (91.2')
LT LEVEE HEIGHT = 12.0' (13.5')
RT LEVEE BUILT TO 89.7' (91.2')
RT LEVEE HEIGHT = 12.0' (13.5')
CHA. VELOCITY = 8.4 FT/SEC (8.4 FT/SEC)
LIMIT OF ROW = 1110' (1115')
STA. 756+20
LT LEVEE BUILT TO 97.5' (99.0')
LT LEVEE HEIGHT = 7.7' (8.5')
RT LEVEE BUILT TO 97.5' (99.0')
RT LEVEE HEIGHT = 6.5' (8.0')
CHA. VELOCITY = 4.0 FT/SEC (4.0 FT/SEC)
LIMIT OF ROW = 2940' (2970')
100-YEAR END OF LT LEVEE CONSTRUCTION
200-YEAR END OF LT LEVEE CONSTRUCTION
STA. 841+20
100-YEAR (200-YEAR) END OF RT LEVEE CONSTRUCTION
UPSTREAM PROJECT LIMITS OF ALTERNATIVE 2 (100-YEAR, 200-YEAR)
CACHE CREEK
JESUS
BOUNDARY
ROAD 94B
CANAL
GRANT
Yolo
Willow Oak School
Browns Corner
Golf Course
Yolo Flyers Country Golf Course
WOODLAND-WATTS AIRPORT
WOODLAND-WATTS
MATCH SHEET 2

SHEET INDEX



BRIDGE REPLACEMENTS		
CREEK	STATION	BRIDGE
CACHE	570+08	SPRR BRIDGE
CACHE	570+82	CACHEVILLE RD BRIDGE

LEGEND

- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

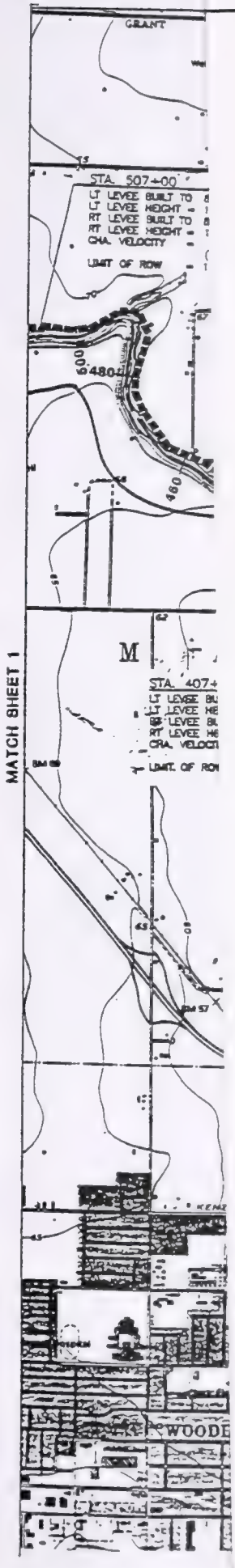
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

CACHE CREEK ALTERNATIVE 2

S.A.W.

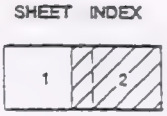
PLATE 14

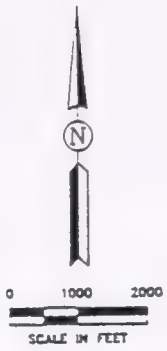


MATCH SHEET 1

ENVIRONMENTAL ENHANCEMENT STATE ENGINEERING

SHEET INDEX





BRIDGE REPLACEMENTS		
CREEK	STATION	BRIDGE
CACHE	401+58	RD 113 BRIDGE

LEGEND

- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' — 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') — 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

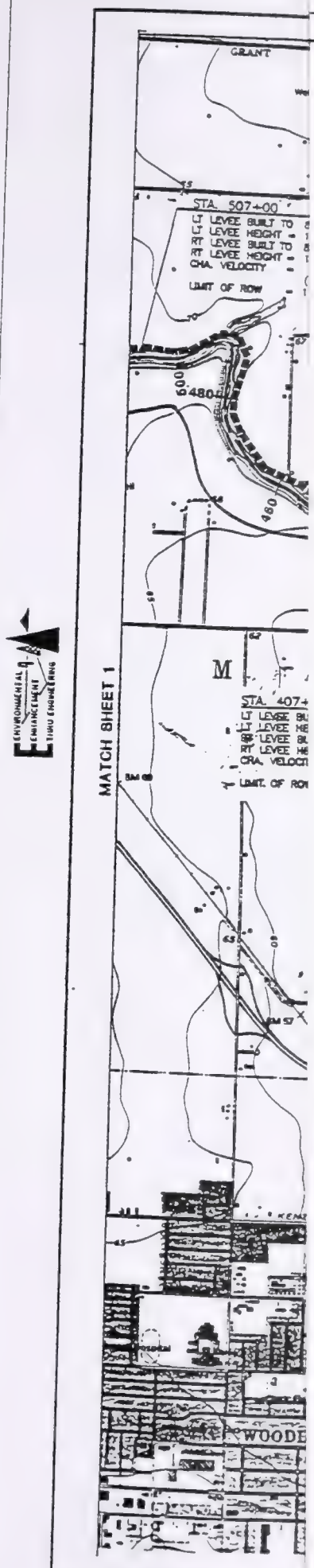
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

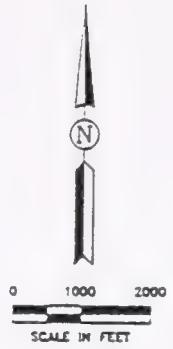
CACHE CREEK ALTERNATIVE 2

S.A.W.

PLATE 15



SHEET INDEX



BRIDGE REPLACEMENTS		
CREEK	STATION	BRIDGE
CACHE	401+58	RD 113 BRIDGE

LEGEND

	CHANNEL CENTERLINE
0	STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
	EXISTING LEVEE
	NEW LEVEE
	RAISE EXISTING LEVEE
	LIMIT OF CHANNEL IMPROVEMENT
	STONE PROTECTION
	REPLACE BRIDGE
	GAGING STATION RELOCATION
11.4'	100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
(12.5')	200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

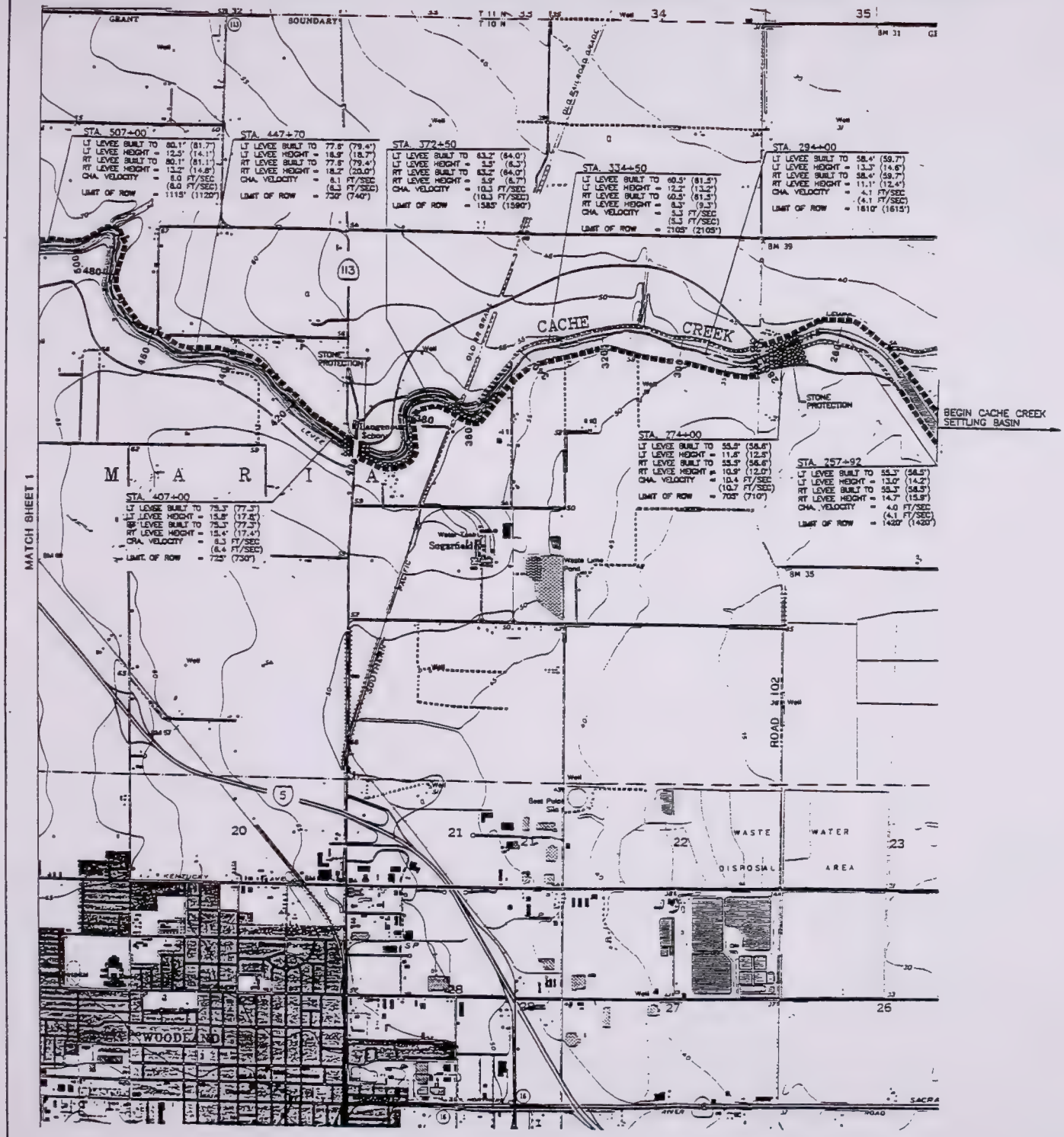
S.A.W.

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

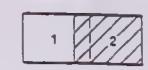
CACHE CREEK ALTERNATIVE 2

2 of 2

PLATE 15


GRANT
BOUNDARY
T 11 N
T 10 N
CACHE CREEK
STONE PROTECTION
BEGIN CACHE CREEK SETTLING BASIN
M A R I A
WOODLAND
ROAD 102
WASTE WATER DISPOSAL AREA
MATCH SHEET 1
STA. 507+00
LT LEVEE BUILT TO 88.1' (81.7')
LT LEVEE HEIGHT = 12.5' (14.1')
RT LEVEE BUILT TO 80.1' (81.1')
RT LEVEE HEIGHT = 13.2' (14.8')
CHA. VELOCITY = 8.0 FT/SEC (8.0 FT/SEC)
LIMIT OF ROW = 1115' (1120')
STA. 447+70
LT LEVEE BUILT TO 77.8' (79.4')
LT LEVEE HEIGHT = 18.9' (18.7')
RT LEVEE BUILT TO 77.8' (79.4')
RT LEVEE HEIGHT = 18.2' (20.0')
CHA. VELOCITY = 8.1 FT/SEC (8.3 FT/SEC)
LIMIT OF ROW = 730' (740')
STA. 372+50
LT LEVEE BUILT TO 63.2' (64.0')
LT LEVEE HEIGHT = 8.9' (8.3')
RT LEVEE BUILT TO 63.2' (64.0')
RT LEVEE HEIGHT = 8.9' (8.7')
CHA. VELOCITY = 10.3 FT/SEC (10.3 FT/SEC)
LIMIT OF ROW = 1585' (1590')
STA. 334+50
LT LEVEE BUILT TO 60.5' (61.5')
LT LEVEE HEIGHT = 12.2' (13.2')
RT LEVEE BUILT TO 60.5' (61.5')
RT LEVEE HEIGHT = 8.3' (9.3')
CHA. VELOCITY = 8.3 FT/SEC (8.3 FT/SEC)
LIMIT OF ROW = 2105' (2105')
STA. 294+00
LT LEVEE BUILT TO 58.4' (59.7')
LT LEVEE HEIGHT = 13.3' (14.6')
RT LEVEE BUILT TO 58.4' (59.7')
RT LEVEE HEIGHT = 11.1' (12.4')
CHA. VELOCITY = 4.1 FT/SEC (4.1 FT/SEC)
LIMIT OF ROW = 1610' (1615')
STA. 274+00
LT LEVEE BUILT TO 55.9' (56.6')
LT LEVEE HEIGHT = 11.6' (12.5')
RT LEVEE BUILT TO 55.9' (56.6')
RT LEVEE HEIGHT = 10.9' (12.0')
CHA. VELOCITY = 10.4 FT/SEC (10.7 FT/SEC)
LIMIT OF ROW = 705' (710')
STA. 257+92
LT LEVEE BUILT TO 55.3' (56.5')
LT LEVEE HEIGHT = 13.0' (14.2')
RT LEVEE BUILT TO 55.3' (56.5')
RT LEVEE HEIGHT = 14.7' (15.9')
CHA. VELOCITY = 4.0 FT/SEC (4.1 FT/SEC)
LIMIT OF ROW = 1420' (1420')
STA. 407+00
LT LEVEE BUILT TO 79.3' (77.3')
LT LEVEE HEIGHT = 15.6' (17.6')
RT LEVEE BUILT TO 79.3' (77.3')
RT LEVEE HEIGHT = 15.4' (17.4')
CHA. VELOCITY = 8.3 FT/SEC (8.4 FT/SEC)
LIMIT OF ROW = 725' (730')

SHEET INDEX



BRIDGE REPLACEMENTS		
CREEK	STATION	BRIDGE
CACHE	401+58	RD 113 BRIDGE

LEGEND

- CHANNEL CENTERLINE
- STATION (IN 100 FEET) ABOVE CONFLUENCE WITH YOLO BYPASS
- EXISTING LEVEE
- NEW LEVEE
- RAISE EXISTING LEVEE
- LIMIT OF CHANNEL IMPROVEMENT
- STONE PROTECTION
- REPLACE BRIDGE
- GAGING STATION RELOCATION
- 11.4' — 100-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)
- (12.5') — 200-YEAR HEIGHT (ELEVATION, VELOCITY, OR ROW WIDTH)

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

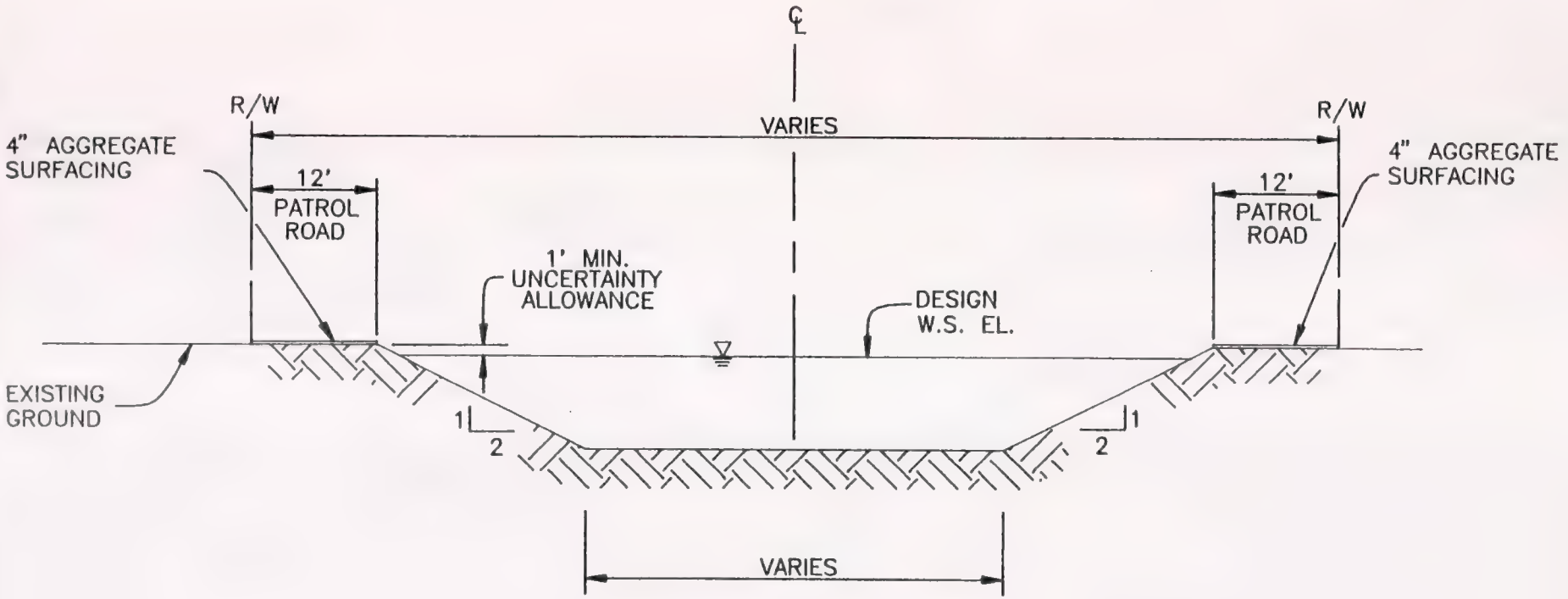
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

CACHE CREEK ALTERNATIVE 2

S.A.W.

2 of 2

PLATE 15



CUT SECTION

NOTE: SLOPE PROTECTION IS REQUIRED ALONG CERTAIN REACHES OF CACHE CREEK. SEE ALTERNATIVE PLANS FOR REQUIRED AREAS. SEE PLATE 19 FOR DETAILS.

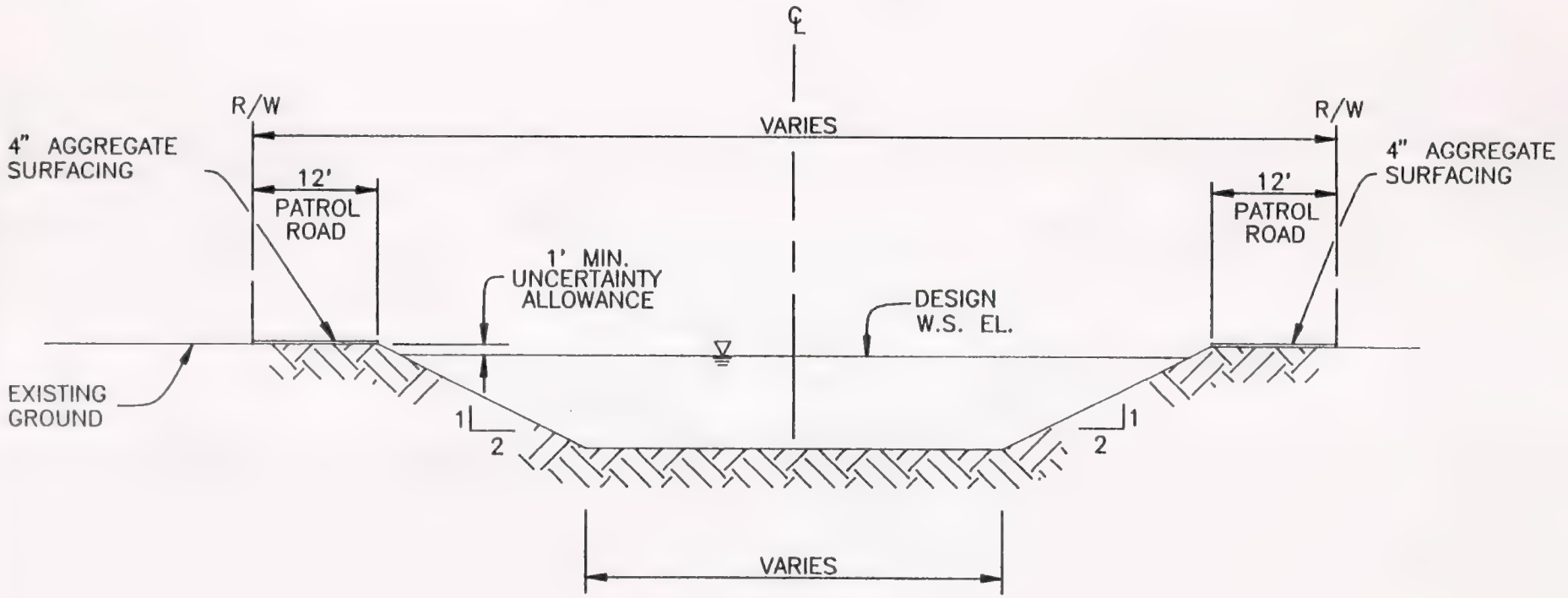
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

TYPICAL CROSS SECTION

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 16

DATE: 3-1-94



CUT SECTION

NOTE: SLOPE PROTECTION IS REQUIRED ALONG CERTAIN REACHES OF CACHE CREEK. SEE ALTERNATIVE PLANS FOR REQUIRED AREAS. SEE PLATE 19 FOR DETAILS.

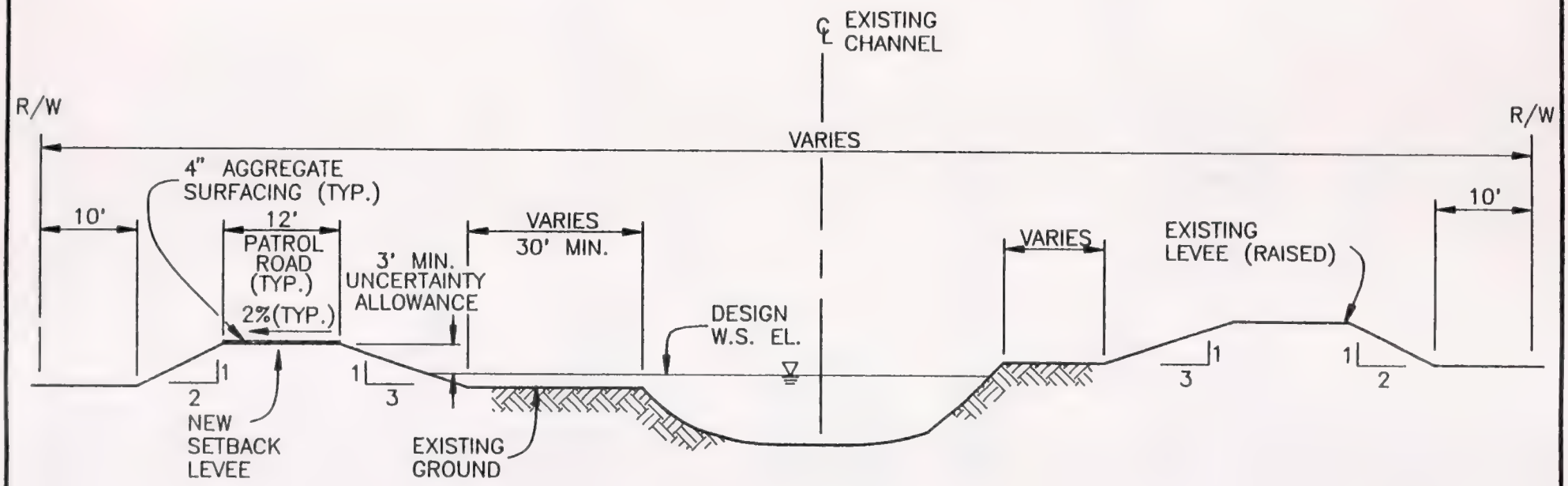
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

TYPICAL CROSS SECTION

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 16

DATE: 3-3-94



EMBANKMENT SECTION

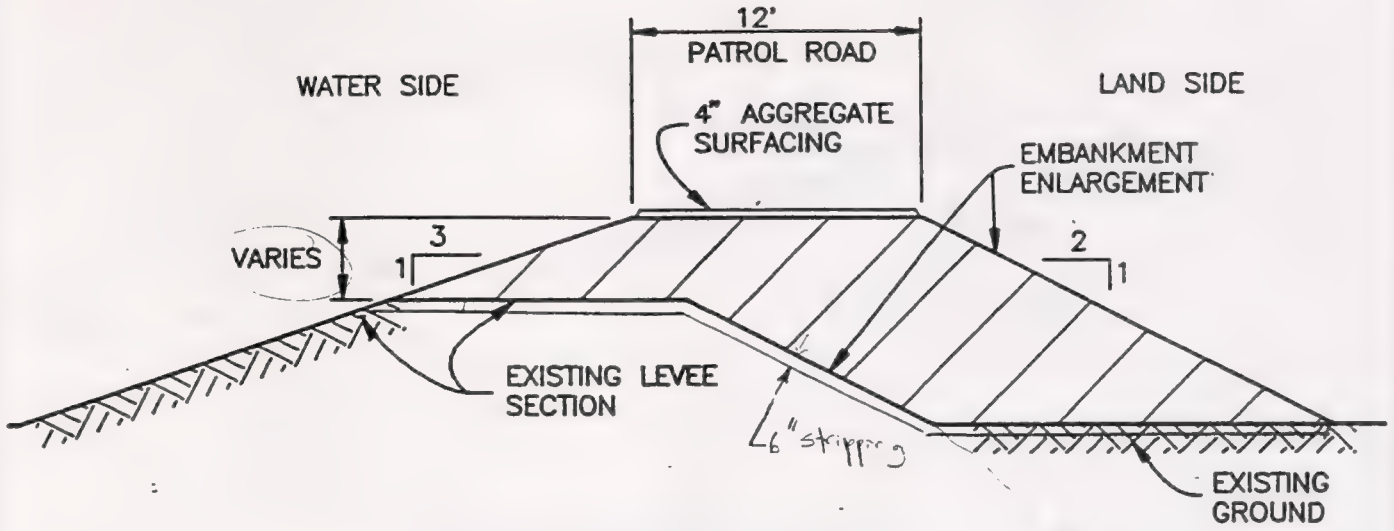
NOTE: SLOPE PROTECTION IS REQUIRED ALONG CERTAIN REACHES OF CACHE CREEK. SEE ALTERNATIVE PLANS FOR REQUIRED AREAS. SEE PLATE 19 FOR DETAILS.

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

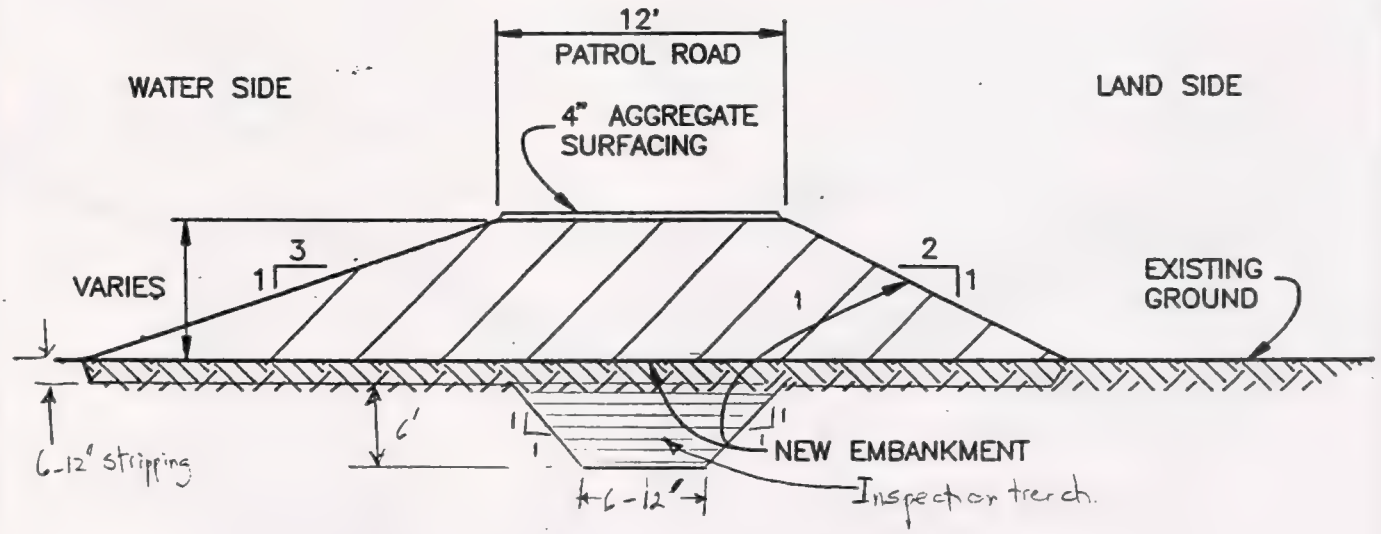
TYPICAL CROSS SECTION

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 17



LAND SIDE LEVEE ENLARGEMENT



NEW LEVEE EMBANKMENT

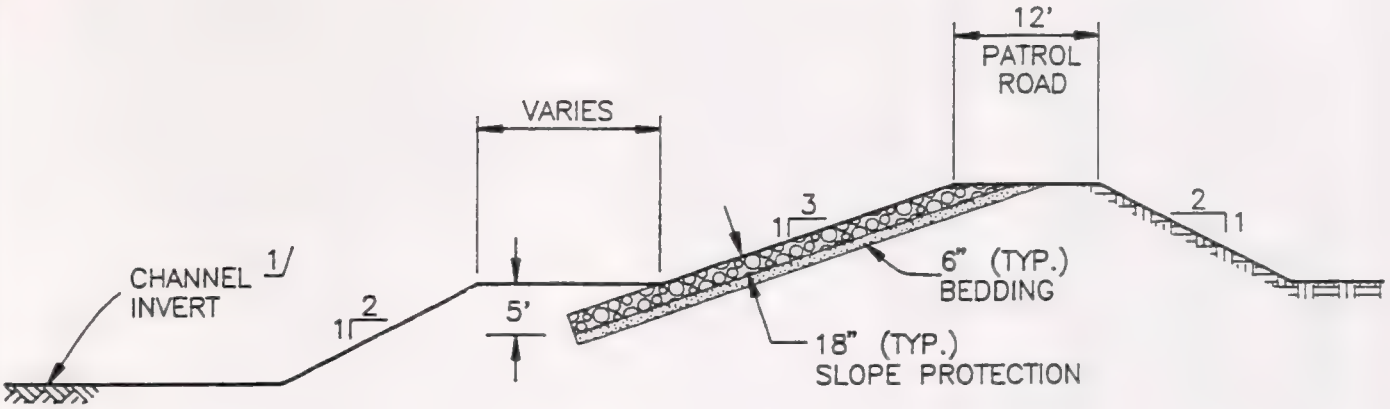
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

TYPICAL LEVEE SECTIONS

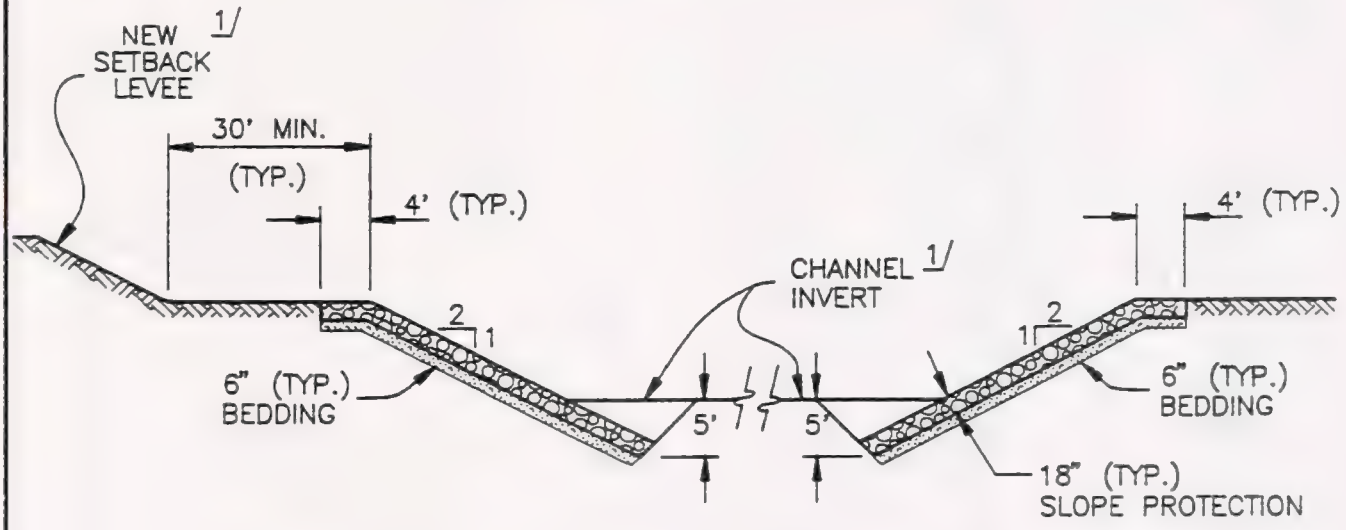
DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 18

DATE: 5-3-94



ADJACENT LEVEE



SETBACK LEVEE/CHANNELIZATION

1/ STONE PROTECTION INCLUDED ON CHANNEL INVERT, CHANNEL SLOPES, AND LEVEES IMMEDIATELY UPSTREAM AND DOWNSTREAM (200') FROM BRIDGES.

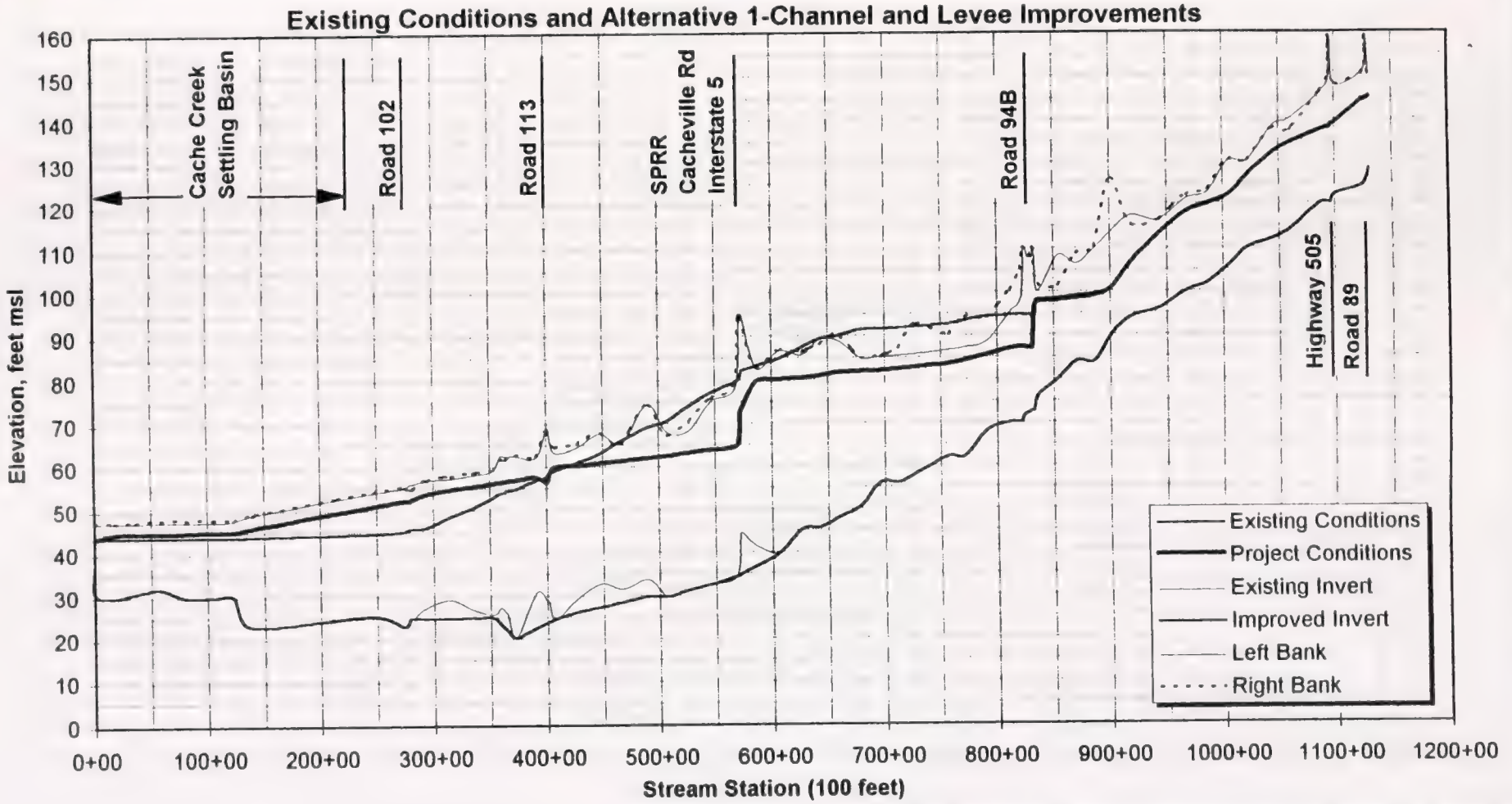
WESTSIDE TRIBUTARIES TO
YOLO BYPASS INVESTIGATION

TYPICAL SLOPE PROTECTION

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 19

DATE: 3-3-94



NOTE: EXISTING CONDITIONS REFLECT DECREASE IN 100-YEAR FLOOD FLOWS DUE TO OVERBANK LOSSES.

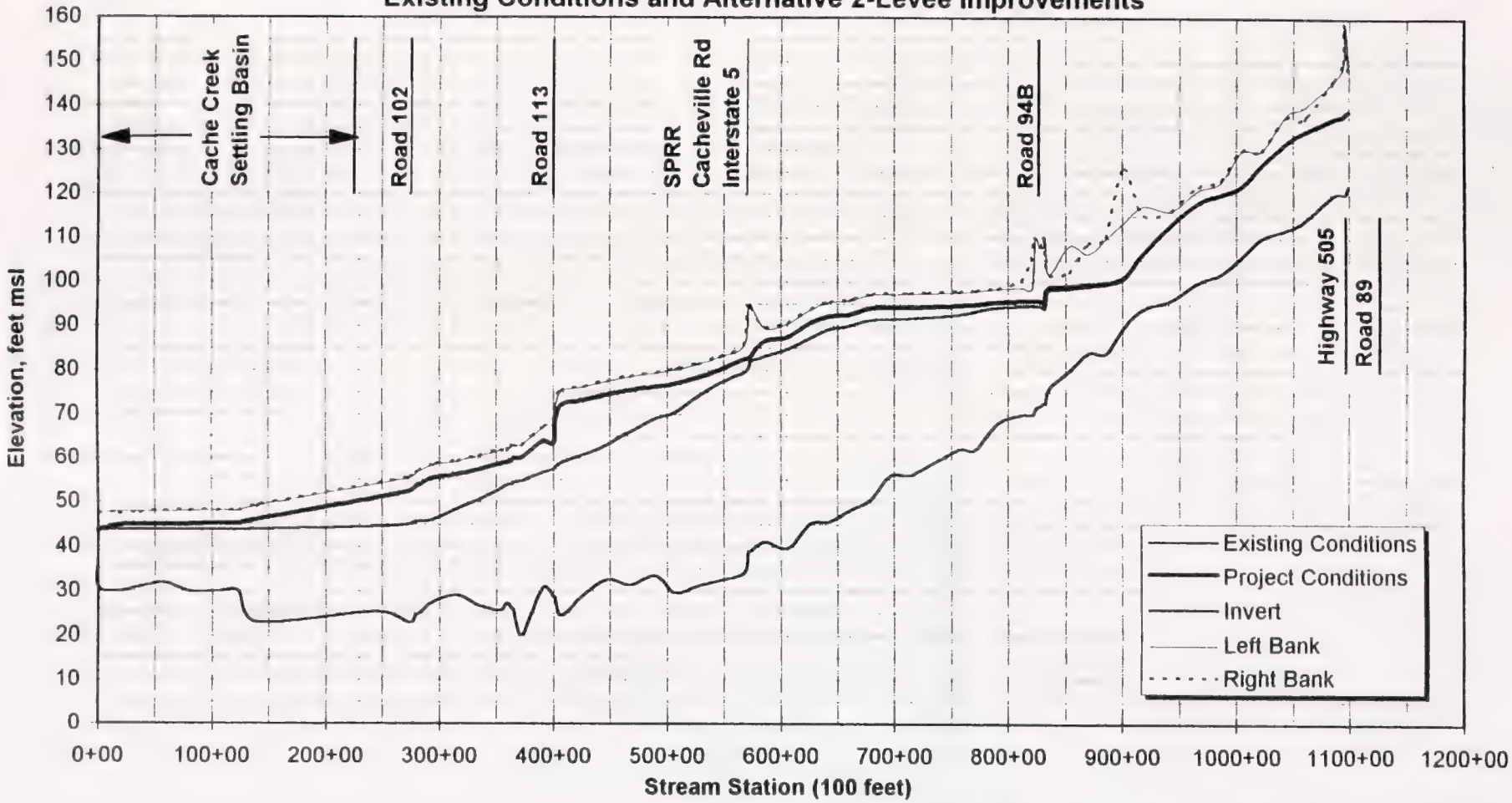
WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

CACHE CREEK 100-YEAR WATER SURFACE PROFILES

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 20

DATE: 3-3-94



NOTE: EXISTING CONDITIONS REFLECT DECREASE IN 100-YEAR FLOOD FLOWS DUE TO OVERBANK LOSSES.

WESTSIDE TRIBUTARIES TO YOLO BYPASS INVESTIGATION

CACHE CREEK 100-YEAR WATER SURFACE PROFILES

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

DATE: MARCH 1994 | PLATE: 21

APPENDIX B
COST ESTIMATES (BELOW ROAD 102)

Table B-1

ALTERNATIVE 1 – CACHE CREEK CHANNEL AND LEVEE IMPROVEMENTS BELOW ROAD 102 100-YEAR FLOOD PROTECTION COST ESTIMATE

FIRST COST

Acct. No.	Description	Estimated Quantity	Unit	Unit Cost, $	Extended Cost, $	Contingency $	Contingency %	Total Cost, $
01	LANDS AND DAMAGES							
	Fee	47	ac		58,800	20,580	35	79,380
	Acquisition Allowance	1	ls	30,000.00	30,000	0	0	30,000
	Total - Lands and Damages				88,800	20,580		109,380
02	RELOCATIONS							
	Utilities	1	ls	55,000.00	55,000	11,000	20	66,000
	Total - Relocations				55,000	11,000		66,000
06	FISH & WILDLIFE MITIGATION	10	%					272,620
	Total - Mitigation							272,620
08	PROJECT ROADS							
	Patrol Road	1,660	ton	12.50	20,750	4,150	20	24,900
	Total - Project Roads				20,750	4,150		24,900
09	CHANNELS AND CANALS							
	Mobilization and Demobilization	1	ls	1,000.00	1,000	250	25	1,250
	Excavation	94,520	cy	2.75	259,930	64,980	25	324,910
	Total - Channels and Canals				260,930	65,230		326,160
11	LEVEES AND FLOODWALLS							
	Mobilization and Demobilization	1	ls	9,000.00	9,000	2,250	25	11,250
	Clearing and Grubbing	48	ac	310.00	14,880	3,720	25	18,600
	Stripping	61	ac	470.00	28,670	7,170	25	35,840
	Embankment	341,002	cy	5.00	1,705,010	426,250	25	2,131,260
	Seeding	48	ac	1,870.00	89,760	22,440	25	112,200
	Total - Levees and Floodwalls				1,847,320	461,830		2,309,150
18	CULTURAL RESOURCES PRESERVATION	1	%					27,260
	Total - Cultural Resources							27,260
	Total Construction Cost							3,135,470
30	PLANNING, ENGINEERING, AND DESIGN	14	%					422,880
31	CONSTRUCTION MANAGEMENT	8	%					241,650
	TOTAL FIRST COST							3,800,000

Table B-1
(continued)

ALTERNATIVE 1 – CACHE CREEK
CHANNEL AND LEVEE IMPROVEMENTS
BELOW ROAD 102
100-YEAR FLOOD PROTECTION
COST ESTIMATE

INVESTMENT COST

	Description	Estimated Quantity	Unit		Total Cost, $
	INTEREST DURING CONSTRUCTION				
	Interest Rate	8.0	%		
	Construction Period	2	yr		
	Year 0.5 (Midpoint of 1st Year)				
	Uniform Construction Expenditure				1,900,000
	Interest During Construction	0.0400	factor		80,000
	Year 1.5 (Midpoint of 2nd Year)				
	Uniform Construction Expenditure				1,900,000
	Interest During Construction	0.1232	factor		230,000
	TOTAL INVESTMENT COST				4,110,000

ANNUAL COST

	Description	Estimated Quantity	Unit	Unit Cost, $	Total Cost, $
	INTEREST AND AMORTIZATION				
	Interest Rate	8.0	%		
	Amortization Period	100	yr		329,000
	OPERATION AND MAINTENANCE				
	Patrol Roads	1.2	mi	500.00	1,000
	Channel Maintenence	0.4	mi	1,500.00	1,000
	Levees	11.9	mi	3,500.00	42,000
		5.6	mi/ft-height	50.00	3,000
	TOTAL ANNUAL COST				376,000

Table B-2

ALTERNATIVE 1 – CACHE CREEK CHANNEL AND LEVEE IMPROVEMENTS BELOW ROAD 102 200-YEAR FLOOD PROTECTION COST ESTIMATE

FIRST COST

Acct. No.	Description	Estimated Quantity	Unit	Unit Cost, $	Extended Cost, $	Contingency $	Contingency %	Total Cost, $
01	LANDS AND DAMAGES							
	Fee	48	ac		59,400	20,790	35	80,190
	Acquisition Allowance	1	ls	30,000.00	30,000	0	0	30,000
	Total - Lands and Damages				89,400	20,790		110,190
02	RELOCATIONS							
	Utilities	1	ls	75,000.00	75,000	15,000	20	90,000
	Total - Relocations				75,000	15,000		90,000
06	FISH & WILDLIFE MITIGATION	10	%					356,690
	Total - Mitigation							356,690
08	PROJECT ROADS							
	Patrol Road	1,660	ton	12.50	20,750	4,150	20	24,900
	Total - Project Roads				20,750	4,150		24,900
09	CHANNELS AND CANALS							
	Mobilization and Demobilization	1	ls	1,000.00	1,000	250	25	1,250
	Excavation	94,520	cy	2.75	259,930	64,980	25	324,910
	Total - Channels and Canals				260,930	65,230		326,160
11	LEVEES AND FLOODWALLS							
	Mobilization and Demobilization	1	ls	12,000.00	12,000	3,000	25	15,000
	Clearing and Grubbing	52	ac	310.00	16,120	4,030	25	20,150
	Stripping	65	ac	470.00	30,550	7,640	25	38,190
	Embankment	468,950	cy	5.00	2,344,750	586,190	25	2,930,940
	Seeding	52	ac	1,870.00	97,240	24,310	25	121,550
	Total - Levees and Floodwalls				2,500,660	625,170		3,125,830
18	CULTURAL RESOURCES PRESERVATION	1	%					35,670
	Total - Cultural Resources							35,670
	Total Construction Cost							4,069,440
30	PLANNING, ENGINEERING, AND DESIGN	14	%					553,990
31	CONSTRUCTION MANAGEMENT	8	%					316,570
	TOTAL FIRST COST							4,940,000

Table B-2
(continued)

ALTERNATIVE 1 – CACHE CREEK CHANNEL AND LEVEE IMPROVEMENTS BELOW ROAD 102 200-YEAR FLOOD PROTECTION COST ESTIMATE

INVESTMENT COST

	Description	Estimated Quantity	Unit		Total Cost, $
	INTEREST DURING CONSTRUCTION				
	Interest Rate	8.0	%		
	Construction Period	2	yr		
	Year 0.5 (Midpoint of 1st Year)				
	Uniform Construction Expenditure				2,470,000
	Interest During Construction	0.0400	factor		100,000
	Year 1.5 (Midpoint of 2nd Year)				
	Uniform Construction Expenditure				2,470,000
	Interest During Construction	0.1232	factor		300,000
	TOTAL INVESTMENT COST				5,340,000

ANNUAL COST

	Description	Estimated Quantity	Unit	Unit Cost, $	Total Cost, $
	INTEREST AND AMORTIZATION				
	Interest Rate	8.0	%		
	Amortization Period	100	yr		427,000
	OPERATION AND MAINTENANCE				
	Patrol Roads	1.2	mi	500.00	1,000
	Channel Maintenence	0.4	mi	1,500.00	1,000
	Levees	11.9	mi	3,500.00	42,000
		6.9	mi/ft-height	50.00	4,000
	TOTAL ANNUAL COST				475,000

Table B-3

ALTERNATIVE 2 – CACHE CREEK LEVEE IMPROVEMENTS BELOW ROAD 102 100-YEAR FLOOD PROTECTION COST ESTIMATE

FIRST COST

Acct. No.	Description	Estimated Quantity	Unit	Unit Cost, $	Extended Cost, $	Contingency $	Contingency %	Total Cost, $
01	LANDS AND DAMAGES							
	Fee	78	ac		262,800	91,980	35	354,780
	Acquisition Allowance	1	ls	30,000.00	30,000	0	0	30,000
	Total - Lands and Damages				292,800	91,980		384,780
02	RELOCATIONS							
	Utilities	1	ls	58,000.00	58,000	11,600	20	69,600
	Total - Relocations				58,000	11,600		69,600
06	FISH & WILDLIFE MITIGATION	10	%					254,330
	Total - Mitigation							254,330
08	PROJECT ROADS							
	Patrol Road	1,660	ton	12.50	20,750	4,150	20	24,900
	Total - Project Roads				20,750	4,150		24,900
11	LEVEES AND FLOODWALLS							
	Mobilization and Demobilization	1	ls	10,000.00	10,000	2,500	25	12,500
	Clearing and Grubbing	49	ac	310.00	15,190	3,800	25	18,990
	Stripping	62	ac	470.00	29,140	7,290	25	36,430
	Embankment	362,980	cy	5.00	1,814,900	453,730	25	2,268,630
	Seeding	48	ac	1,870.00	89,760	22,440	25	112,200
	Total - Levees and Floodwalls				1,958,990	489,760		2,448,750
18	CULTURAL RESOURCES PRESERVATION	1	%					25,430
	Total - Cultural Resources							25,430
	Total Construction Cost							3,207,790
30	PLANNING, ENGINEERING, AND DESIGN	14	%					395,950
31	CONSTRUCTION MANAGEMENT	8	%					226,260
	TOTAL FIRST COST							3,830,000

Table B-3
(continued)

ALTERNATIVE 2 – CACHE CREEK
LEVEE IMPROVEMENTS
BELOW ROAD 102
100-YEAR FLOOD PROTECTION
COST ESTIMATE

INVESTMENT COST

	Description	Estimated Quantity	Unit		Total Cost, $
	INTEREST DURING CONSTRUCTION				
	Interest Rate	8.0	%		
	Construction Period	2	yr		
	Year 0.5 (Midpoint of 1st Year)				
	Uniform Construction Expenditure				1,915,000
	Interest During Construction	0.0400	factor		80,000
	Year 1.5 (Midpoint of 2nd Year)				
	Uniform Construction Expenditure				1,915,000
	Interest During Construction	0.1232	factor		240,000
	TOTAL INVESTMENT COST				4,150,000

ANNUAL COST

	Description	Estimated Quantity	Unit	Unit Cost, $	Total Cost, $
	INTEREST AND AMORTIZATION				
	Interest Rate	8.0	%		
	Amortization Period	100	yr		332,000
	OPERATION AND MAINTENANCE				
	Patrol Roads	1.2	mi	500.00	1,000
	Levees	11.8	mi	3,500.00	41,000
		6.2	mi/ft-height	50.00	4,000
	TOTAL ANNUAL COST				378,000

Table B-4

ALTERNATIVE 2 – CACHE CREEK LEVEE IMPROVEMENTS BELOW ROAD 102 200-YEAR FLOOD PROTECTION COST ESTIMATE

FIRST COST

Acct. No.	Description	Estimated Quantity	Unit	Unit Cost, $	Extended Cost, $	Contingency $	Contingency %	Total Cost, $
01	LANDS AND DAMAGES							
	Fee	78	ac		263,800	92,330	35	356,130
	Acquisition Allowance	1	ls	30,000.00	30,000	0	0	30,000
	Total - Lands and Damages				293,800	92,330		386,130
02	RELOCATIONS							
	Utilities	1	ls	79,000.00	79,000	15,800	20	94,800
	Total - Relocations				79,000	15,800		94,800
06	FISH & WILDLIFE MITIGATION	10	%					340,840
	Total - Mitigation							340,840
08	PROJECT ROADS							
	Patrol road	1,660	ton	12.50	20,750	4,150	20	24,900
	Total - Project Roads				20,750	4,150		24,900
11	LEVEES AND FLOODWALLS							
	Mobilization and Demobilization	1	ls	13,000.00	13,000	3,250	25	16,250
	Clearing and Grubbing	54	ac	310.00	16,740	4,190	25	20,930
	Stripping	66	ac	470.00	31,020	7,760	25	38,780
	Embankment	494,212	cy	5.00	2,471,060	617,770	25	3,088,830
	Seeding	53	ac	1,870.00	99,110	24,780	25	123,890
	Total - Levees and Floodwalls				2,630,930	657,750		3,288,680
18	CULTURAL RESOURCES PRESERVATION	1	%					34,080
	Total - Cultural Resources							34,080
	Total Construction Cost							4,169,430
30	PLANNING, ENGINEERING, AND DESIGN	14	%					528,550
31	CONSTRUCTION MANAGEMENT	8	%					302,020
	TOTAL FIRST COST							5,000,000

Table B-4
(continued)

ALTERNATIVE 2 – CACHE CREEK LEVEE IMPROVEMENTS BELOW ROAD 102 200-YEAR FLOOD PROTECTION COST ESTIMATE

INVESTMENT COST

	Description	Estimated Quantity	Unit		Total Cost, $
	INTEREST DURING CONSTRUCTION				
	Interest Rate	8.0	%		
	Construction Period	2	yr		
	Year 0.5 (Midpoint of 1st Year)				
	Uniform Construction Expenditure				2,500,000
	Interest During Construction	0.0400	factor		100,000
	Year 1.5 (Midpoint of 2nd Year)				
	Uniform Construction Expenditure				2,500,000
	Interest During Construction	0.1232	factor		310,000
	TOTAL INVESTMENT COST				5,410,000

ANNUAL COST

	Description	Estimated Quantity	Unit	Unit Cost, $	Total Cost, $
	INTEREST AND AMORTIZATION				
	InterestRate	8.0	%		
	Amortization Period	100	yr		433,000
	OPERATION AND MAINTENANCE				
	Patrol Roads	1.2	mi	500.00	1,000
	Levees	11.8	mi	3,500.00	41,000
		7.1	mi/ft-height	50.00	4,000
	TOTAL ANNUAL COST				479,000

APPENDIX C
DETENTION STORAGE COSTS

APPENDIX C

DETENTION STORAGE COSTS

Appendix C presents a description of the project features and cost estimates for detention storage on Bear Creek. Estimates have been developed assuming storage volumes equal to 100 percent of the turnoff occurring upstream of the dam site for the 100- and 200-year storm events.

Based upon preliminary screening results, a detention reservoir on Bear Creek, approximately 11 miles above the confluence with Cache Creek, warranted further study. Previous water supply studies have determined that a large multipurpose reservoir (1,100,000-1,975,000 acre-feet) was physically possible. Because the location of the recommended dam site (southern end of Bear Valley) is in the upper reaches of the Cache Creek watershed above Capay Dam, the hydrograph volume for the 100-year flood is relatively small (26,000 acre-feet) by comparison.

The dam embankment would be constructed on Bear Creek near Coyote Peak. An embankment height of approximately 71 feet would be needed to impound the 100-year hydrograph and 73 feet for the 200-year storm.

The area of inundation to the 100-year event would be about 1,120 acres and approximately 1,270 acres would be flooded during the 200-year event if that entire flood was contained behind the dam.

Right-of-way requirements for the Bear Creek Reservoir and Dam were determined from a preliminary reservoir rating curve (elevation vs. area vs. storage) and an approximate embankment configuration.

Using the proposed reservoir sizes (26,000 acre-feet for the 100-year and 29,000 acre-feet for the 200-year) and information derived from the Arroyo Pasajero Project, dam site costs were developed. A unit dam site development cost of $700 per acre-foot, based upon the Arroyo Pasajero Project, was applied to the Bear Creek site. Average unit right-of-way costs were used for flood easements (reservoir pool areas) and fee takes (area beneath the dam embankment).

The estimated costs for detention storage on Bear Creek for 26,000 acre-feet and 29,000 acre-feet of storage are presented in Tables C-1 and C-2, respectively.

Table C-1

CACHE CREEK
100-YEAR FLOOD DETENTION ON BEAR CREEK
COST ESTIMATE

FIRST COST

Acct. No.	Description	Estimated Quantity	Unit	Unit Cost, $	Extended Cost, $	Contingency $	Contingency %	Total Cost, $
01	LANDS AND DAMAGES							
	Fee	1,120	ac		422,240	147,780	35	570,020
	Acquisition Allowance	1	ls	30,000.00	30,000	0	0	30,000
	Total - Lands and Damages				452,240	147,780		600,020
06	FISH & WILDLIFE MITIGATION	10	%					6,532,500
	Total - Mitigation							6,532,500
03	RESERVOIRS							
	Mobilization and Demobilization	1	ls	260,000.00	260,000	65,000	25	325,000
	Embankment and Appurtenance	26,000	af	2,000.00	52,000,000	13,000,000	25	65,000,000
	Total - Reservoirs				52,260,000	13,065,000		65,325,000
18	CULTURAL RESOURCES PRESERVATION	1	%					653,250
	Total - Cultural Resources							653,250
	Total Construction Cost							73,110,770
30	PLANNING, ENGINEERING, AND DESIGN	14	%					10,149,510
31	CONSTRUCTION MANAGEMENT	8	%					5,799,720
	TOTAL FIRST COST							89,060,000

INVESTMENT COST

	Description	Estimated Quantity	Unit		Total Cost, $
	INTEREST DURING CONSTRUCTION				
	Interest Rate	8.0	%		
	Construction Period	2	yr		
	Year 0.5 (Midpoint of 1st Year)				
	Uniform Construction Expenditure				44,530,000
	Interest During Construction	0.0400	factor		1,780,000
	Year 1.5 (Midpoint of 2nd Year)				
	Uniform Construction Expenditure				44,530,000
	Interest During Construction	0.1232	factor		5,490,000
	TOTAL INVESTMENT COST				96,330,000

ANNUAL COST

	Description	Estimated Quantity	Unit	Unit Cost, $	Total Cost, $
	INTEREST AND AMORTIZATION				
	Interest Rate	8.0	%		
	Amortization Period	100	yr		7,710,000
	OPERATION AND MAINTENANCE				
	Reservoirs	0.5	%		327,000
	TOTAL ANNUAL COST				8,037,000

Table C-2

CACHE CREEK
200-YEAR FLOOD DETENTION ON BEAR CREEK
COST ESTIMATE

FIRST COST

Acct. No.	Description	Estimated Quantity	Unit	Unit Cost, $	Extended Cost, $	Contingency $	Contingency %	Total Cost, $
01	LANDS AND DAMAGES							
	Fee	1,270	ac		478,790	167,580	35	646,370
	Acquisition Allowance	1	ls	30,000.00	30,000	0	0	30,000
	Total - Lands and Damages				508,790	167,580		676,370
06	FISH & WILDLIFE MITIGATION	10	%					7,286,250
	Total - Mitigation							7,286,250
03	RESERVOIRS							
	Mobilization and Demobilization	1	ls	290,000.00	290,000	72,500	25	362,500
	Embankment and Appurtenance	29,000	af	2,000.00	58,000,000	14,500,000	25	72,500,000
	Total - Reservoirs				58,290,000	14,572,500		72,862,500
18	CULTURAL RESOURCES PRESERVATION	1	%					728,630
	Total - Cultural Resources							728,630
	Total Construction Cost							81,553,750
30	PLANNING, ENGINEERING, AND DESIGN	14	%					11,324,890
31	CONSTRUCTION MANAGEMENT	8	%					6,471,360
	TOTAL FIRST COST							99,350,000

INVESTMENT COST

	Description	Estimated Quantity	Unit		Total Cost, $
	INTEREST DURING CONSTRUCTION				
	Interest Rate	8.0	%		
	Construction Period	2	yr		
	Year 0.5 (Midpoint of 1st Year)				
	Uniform Construction Expenditure				49,675,000
	Interest During Construction	0.0400	factor		1,990,000
	Year 1.5 (Midpoint of 2nd Year)				
	Uniform Construction Expenditure				49,675,000
	Interest During Construction	0.1232	factor		6,120,000
	TOTAL INVESTMENT COST				107,460,000

ANNUAL COST

	Description	Estimated Quantity	Unit	Unit Cost, $	Total Cost, $
	INTEREST AND AMORTIZATION				
	Interest Rate	8.0	%		
	Amortization Period	100	yr		8,601,000
	OPERATION AND MAINTENANCE				
	Reservoirs	0.5	%		364,000
	TOTAL ANNUAL COST				8,965,000

APPENDIX D
REAL ESTATE REPORT

SEE APPENDIX D TO MAIN REPORT
(follows this section)

APPENDIX D

REAL ESTATE REPORT

REAL ESTATE APPENDIX
RECONNAISSANCE COST ESTIMATE

WESTSIDE TRIBUTARIES
YOLO/COLUSA COUNTY, CALIFORNIA

PREPARED BY: WIRTH REAL ESTATE / VALUATION SERVICES
A/E FIRM: BORCALLI & ASSOCIATES
CLIENT: ARMY CORPS OF ENGINEERS / SACRAMENTO DISTRICT

REAL ESTATE APPENDIX

WESTSIDE TRIBUTARIES TO YOLO BYPASS
RECONNAISSANCE COST ESTIMATE
YOLO/COLUSA COUNTY, CALIFORNIA

1.) GENERAL DESCRIPTION OF REAL ESTATE REQUIREMENTS

The real estate cost estimates for this reconnaissance level report are for the proposed acquisition of specified property rights related to land, improvements, mitigation/restoration, and potential severance damage for the Westside Tributaries to the Yolo Bypass Project. The report provides a real estate cost analyses of three options on the Cache Creek drainage area for improved flood control protection. Alternative #1 entails stream channel excavation and slope protection along existing levees in Cache Creek, below Stevens Bridge to the Cache Creek Settling Basin, in Yolo County. Alternative #2 studies the feasibility of constructing a series of new offset levees parallel with the existing high banks of Cache Creek in the same reach of Cache Creek as identified in Alternative #1. Additional option is provided through "Bear Creek Reservoir". This option defines construction of a reservoir on a tributary of Cache Creek in the upper reaches of the Cache Creek watershed, known as "Bear Valley and Bear Creek" in western Colusa County.

The study area is segmented into two separate locations. The first area is situated in a small inter-mountain valley of the Coast Range known as Bear Valley and is focused along Bear Creek, a year-round tributary to Cache Creek. The valley is devoted to livestock ranching and recreational uses and is unpopulated, excepting a couple of ranch headquarters. The land ownerships tend toward large spreads in the thousands of acres.

The second area is located in the lower plain of the Central Valley region along Cache Creek. Land uses are primarily agricultural, and classified as open, prime, irrigated, row cropland and orchard plantings. The project area is sparsely populated, including the small unincorporated farming community of Yolo along Interstate 5, and small residential clusters and scattered rural residential homesites. Other non-ag uses along Cache Creek include commercial gravel mining. Cache Creek is known for its high quality aggregate material and has provided a supply of construction aggregate since the early 1900's. Below Stevens Bridge there are three gravel extraction and processing operations in the study area.

The land ownerships are more parceled and under more diverse ownership in the Alternatives #1 and #2 project study areas. The primary land classification is open, prime ag land, greater than 80 acres. Unit values are assigned to the following land use classifications:

1. Open, prime irrigated ag land >80 acres
2. Open, prime irrigated ag land 40>79 acres
3. Open, prime irrigated ag land 20>39 acres
4. Open, prime irrigated ag land 10>19 acres
5. Orchards >80 acres
6. Orchards 40>79 acres
7. Orchards 20>39 acres
8. Orchards 10>19 acres
9. Surface Mining
10. Winter Grazing/Range
11. Riparian/Recreational

A major portion of the project study area is located on land protected by the Williamson Act and zoned Ag Preserve (A-P). The purpose of the A-P zone is to preserve land best suited for agricultural use from encroachment of nonagricultural uses. The A-P zone is used to set up agricultural preserves in accordance with the California Land Conservation Act of 1965, otherwise known as the Williamson Act. Land not within the A-P zone is zoned A-1 or Ag General. The purpose of the A-1 zone is also to preserve ag lands from the encroachment of incompatible uses and preserves in use transitional type property. A special zone designation in the project study area is SG or Sand and Gravel. This is an overlay zone over either AP or A-1 zoned lands.

2.) ESTATES

Real Estate Cost Estimates in this Reconnaissance Report are predominantly stated as those of the Fee Simple Estate. However, the proposed estates are the standard government estates. Per Unit (Acre) estimates were developed for each of the sections within the identified options based on land usage characteristics adjacent to those sections. Final developed areas identified by the study were applied in extension to cost estimates. The per unit estimates were developed without detailed knowledge of the proposed improvement areas and as such a contingency factor of 25% has been chosen for application in this cost estimate. Because of extensive use restrictions which may be placed upon flowage areas between levee and creek in the Alternative #2 the acquisition cost estimate will be stated in fee value terms. No specific mitigation lands have been identified for cost estimate consideration.

3.) PUBLIC LAW 91-646 RELOCATION AND BENEFITS

Portions of Option #3 of the proposed project appear to require acquisition of several rural residential farmsteads, so some relocations are projected. The analysis does include, where felt to be appropriate, estimated relocation allowance based upon previous relocation history and experience of the Sacramento District Army Corps of Engineers. The estimates utilized are in the amount of $22,500 for home owners, $5,250 for renters, and $20,000 for business relocation. The above estimates applied per estimated occurrence within certain sections of the study area where felt to be appropriate.

4.) UTILITY RELOCATIONS

The project scope of work considers a wide area with a high likely hood that some utility relocation would occur. There are no specified utility relocations contained in the real estate cost estimates, although the contingency factor utilized assumes there may be some relocation cost related to utility relocation.

5.) SPONSOR

Although no specific sponsorship has been delineated for the various portions of the project, it is assumed that both the City of Woodland and the Counties of Yolo/Colusa as well as the Yolo County Flood Control & Water Conservation District and potentially others concerned with flood control measures would be actively involved in the scope of this work. The State Department of Water Resources (San Joaquin-Sacramento Drainage District) has been involved in acquisitions concerning at least portions of the herein considered scope of real estate activities and has conducted similar reconnaissance cost estimates.

6.) BASELINE COST ESTIMATES

Included in the following baseline estimate for real estate costs are estimated cost for lands and estimated improvement costs. Separate line estimates are also provided for PL 91-646 Relocations, Contingency, Severance, and Acquisition Allowance. The Contingency factor is 25% for this study. The estimated severance factor is 10%. The Administrative Cost is estimated to be a total of $30,000 per parcel ($10,000 Federal and $20,000 Non-Federal).

ALTERNATIVE #1 - CACHE CREEK CHANNEL EXCAVATION

CHANNEL EXCAVATION	Acres Req.	Owner Ship		
ESTATE: Fee Acquisition Est. Acres (100 Year) (200 Year)	 695 778	 50 50	 Cost 100 Year	 Cost 200 Year
LAND & IMPROVEMENT:			$2,899,300	$3,579,500
Subtotal:			$2,899,300	$3,579,500
CONTINGENCIES (25%):			$724,800	$894,900
Subtotal:			$3,624,100	$4,474,400
ESTIMATED SEVERANCE (10%):			$289,900	$357,900
Subtotal:			$3,914,000	$4,832,300
PL 91-646 RELOCATIONS:			$-0-	$-0-
Subtotal:			$3,914,000	$4,832,300
ADMINISTRATIVE COST:			$1,500,000	$1,500,000
TOTAL REAL ESTATE COST ------>			$5,414,000	$6,332,300

ALTERNATIVE #2 - CACHE CREEK OFFSET LEVEE

OFFSET LEVEE	Acres Req.	Own-er Ship		
ESTATE: Fee Acquisition Est. Acres (100 Year) (200 Year)	1,721 1,729	50 50	Cost 100 Year	Cost 200 Year
LAND & IMPROVEMENT:			$10,648,100	$10,683,700
Subtotal:			$10,648,100	$10,683,700
CONTINGENCIES (25%):			$2,662,000	$2,670,900
Subtotal:			$13,310,100	$13,354,600
ESTIMATED SEVERANCE (10%):			$1,064,800	$1,068,400
Subtotal:			$14,374,900	$14,423,000
PL 91-646 RELOCATIONS:			$90,000	$90,000
Subtotal:			$14,464,900	$14,513,000
ADMINISTRATIVE COST:			$1,500,000	$1,500,000
TOTAL REAL ESTATE COST ------>			$15,964,900	$16,013,000

BEAR CREEK RESERVOIR

BEAR CREEK RESERVOIR	Acres Req.	Owner Ship		
ESTATE: Fee Acquisition Est. Acres (100 Year) (200 Year)	 1,120 1,270	 1 1	Cost 100 Year	Cost 200 Year
LAND & IMPROVEMENT:			$422,200	$478,800
Subtotal:			$422,200	$478,800
CONTINGENCIES (25%):			$105,600	$119,700
Subtotal:			$527,800	$598,500
ESTIMATED SEVERANCE (10%):			$42,200	$47,900
Subtotal:			$570,000	$646,400
PL 91-646 RELOCATIONS:			$-0-	$-0-
Subtotal:			$570,000	$646,400
ADMINISTRATIVE COST:			$30,000	$30,000
TOTAL REAL ESTATE COST ------>			$600,000	$676,400

SUMMARY TOTAL COSTS / ALTERNATIVES

	TOTAL EST. COSTS	
	100 Year	200 Year
ALTERNATIVE #1 - CACHE CREEK EXCAVATION	$5,414,000	$6,332,300
ALTERNATIVE #2 - CACHE CREEK OFFSET LEVEES	$15,964,900	$16,013,000
OPTION - BEAR CREEK RESERVOIR	$600,000	$676,400

7.) PROJECT MAPPING

A map showing the general boundaries and study area concerning the Westside Tributaries is included with the Basis of Design and Cost Estimates Report. Photos and U.S.G.S. topographic maps are available with supporting real estate reconnaissance cost estimate in the final appraisal report.

8.) MINERAL ACTIVITY

The western section of the Cache Creek study area has a fairly extensive aggregate mining history with minable gravel deposits, both on and off channel. The area surrounding the mined areas is made up of predominantly agricultural land uses and ag land use designations. An aggregate resource overlay or combining zone has been established in the general plan. The off-channel deposits are known to be fairly extensive, but overlaid with prime topsoil. The deposits are of considerable value to the owners as they represent competitive aggregate resource for some local construction firms. The reserves are considered to be of fairly good quality and volume. Consideration for this resource was applied to the in-channel areas only.

CESPK-RE-C 17 June 1994

MEMORANDUM FOR Chief, Planning Division, ATTN: Sacramento Basin Branch (Irene Davies)

SUBJECT: Real Estate Division Approval, Westside Tributaries to Yolo Bypass, Final Reconnaissance Report, Land Cost Requirements

For the purposes of this final reconnaissance report, Engineering and Planning Divisions have estimated certain project costs based on applicable contingency factors of prior studies. Due to the lack of specific detail at the time the Real Estate cost estimate was prepared, land costs and land right requirements for project mitigation, relocation costs for utilities and railroad crossings, fencing, temporary construction sites, borrow sites, and disposal sites were not included. As the project moves into feasibility phase, these items must be analyzed for detailed land costs. Therefore, additional land rights may be required above that stated in the text of the report. Any reference to land cost related to any above item is for estimation purposes and has not been validated by Real Estate Division.

MICHAEL BAIN
Chief, Acquisition Branch
Real Estate Division

APPENDIX E

ECONOMIC ANALYSIS

RECONNAISSANCE STUDY

ECONOMIC ANALYSIS

WESTSIDE TRIBUTARIES TO YOLO BYPASS, CALIFORNIA

U.S. Army Corps Of Engineers
Sacramento District
Economics Branch
April 1994

Basis of Economic Analysis
Westside Tributaries to Yolo Bypass, California
Reconnaissance Study
(April 1994)

INTRODUCTION

The purpose of this report is to describe flood damage data and procedures used in computing future annual flood damages for without and with project conditions. This analysis is based on a 100 year project life (2000-2100), October 1993 price levels, and a 8 percent interest rate. Economic benefits have been developed in accordance with ER-1105-2-100.

FLOOD PLAIN INVENTORY

Flood Plain Reach

This study consists of 4 reaches which covers about 10,914 acres. The northern part of the City of Woodland and the town of Yolo are within the study area. Also included are lands northwest and east of the Woodland City limits. (See Figure 1)

Reach 1 - The northern boundary of Reach 1 runs approximately along Road 16, while the western part of the reach travels about 1/2 mile east of Acacia Canal (Road 95). The southern section follows Cache Creek, and from the east, the reach continues down Cache Creek. Reach 1 has 1,572 acres in the 500-year, 100-year, 50-year flood plains.

Reach 2 - This reach includes the town of Yolo. The northeast boundary of the reach lies approximately 1/2 of a mile south of Road 16A, while the southeast part of the reach is defined by Cache Creek. The southwestern section travels along the Southern Pacific Railroad, and the northwestern boundary is located between the Southern Pacific Railroad and Road 16A. The reach involves the 500-year, 100-year, and 50-year flood plain which cover 236 acres.

Reach 3 - Reach 3 is mainly a non-urban reach which includes the area above Cache Creek and east of Road 99A. The northeastern boundary lies between Road 100 and Road 101. The eastern boundary is defined by Road 101. The southern limit is defined by Cache Creek, and the western section almost reaches Road 99A. There are 568 acres in the 500-year, 100-year, and 50-year flood plain.

Reach 4 - This reach contains the northern part of the City of Woodland. The upper most northern boundary and western boundary are defined by Cache Creek. The southern limit runs along Clover St., while the eastern boundary is approximately Road 102. The area

REACH 1
REACH 2
REACH 3
REACH 4
YOLO1.DAT
YOLO2.DAT
YOLO3.DAT
YOLO4.DAT
WDLND.DAT
WDLNDR.DAT
WDLNDI.DAT
NO FLOODING
NO FLOODING
NO FLOODING
WOODLAND

Figure 1

encompassed in this reach is 8,538 acres, which is the same for all three flood plains, the 500-year, 100-year, and 50-year.

Land Use in the Flood Plain

The three flood plains that were analyzed consist of; the 500-year, 100-year, and 50-year. Due to the fact that the three flood plains are the same in size, the acreage for all three are equal. The 500-year, 100-year, and 50-year each have a total of 10,914 acres, 7,786 of those acres are in agriculture, and 3,128 acres consisting of urban areas.

Determining the present land use in the flood plain was possible with the use of aerial photographs, visual inspection, agricultural land use maps, county assessor roles, zoning maps, and city and county General Plans. The land use categories are shown below.

Land Use Designations

1) Single Family Residential
2) Multiple Family Residential
3) Mobile Home
4) Farmstead
5) Commercial
6) Industrial
7) Public
8) Agriculture

Physical Units

There are 3,554 structures in the 500, 100, and 50-year flood plain. See Table 1 for a complete breakdown of the number of units for each land use category of each reach.

Value of Property

The value of structures were determined by using the Yolo County Assessors Rolls, and discussions with local real estate professionals and county Assessor officials. The values, by land use, from the rolls were adjusted to reflect current depreciated values. Because of California's "Proposition 13", the direct use of assessors values is not possible. Proposition 13 allows assessors values to increase at a maximum rate of two percent per year after a property is sold. At the time of sale the property value is brought up to current market (depreciated) value. Sales dates were noted and the two percent per year increase was compared to the Marshall and Swifts Valuation Service changes in construction prices for the same period and the differences were applied to the assessed value of each property to determine the October

TABLE 1

TOTAL DAMAGEABLE UNITS BY LAND USE CATEGORY

REACH 1	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL	0	0	0
MULTI-RESIDENTIAL	0	0	0
FARMSTEAD	60	60	60
MOBILE HOMES	0	0	0
COMMERCIAL	2	2	2
INDUSTRIAL	0	0	0
PUBLIC	0	0	0
TOTALS	62	62	62

REACH 2	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL	97	97	97
MULTI-RESIDENTIAL	26	26	26
FARMSTEAD	16	16	16
MOBILE HOMES	178	178	178
COMMERCIAL	5	5	5
INDUSTRIAL	0	0	0
PUBLIC	8	8	8
TOTALS	330	330	330

REACH 3	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL	0	0	0
MULTI-RESIDENTIAL	0	0	0
FARMSTEAD	30	30	30
MOBILE HOMES	0	0	0
COMMERCIAL	0	0	0
INDUSTRIAL	0	0	0
PUBLIC	0	0	0
TOTALS	30	30	30

REACH 4	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL	1,991	1,991	1,991
MULTI-RESIDENTIAL	707	707	707
FARMSTEAD	110	110	110
MOBILE HOMES	13	13	13
COMMERCIAL	97	97	97
INDUSTRIAL	183	183	183
PUBLIC	31	31	31
TOTALS	3,132	3,132	3,132

TABLE 1
(Continued)

TOTAL UNITS IN REACHES 1-4

REACH 1-4	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL	2,088	2,088	2,088
MULTI-RESIDENTIAL	733	733	733
FARMSTEAD	216	216	216
MOBILE HOMES	191	191	191
COMMERCIAL	104	104	104
INDUSTRIAL	183	183	183
PUBLIC	39	39	39
TOTALS	**3,554**	**3,554**	**3,554**

1993 value. A sampling of structure values were cross checked by using another method. Square footage was first estimated and then a Marshall and Swift per square foot construction cost was applied. Next depreciation was estimated based on the age and condition of the structure and then the Marshall and Swift value was reduced accordingly. This method compared favorably with the methodology that was used. On site inspections of all properties were made to determine foundation heights and the number of stories.

The market value (depreciated value) of damageable property, which includes all structures and contents in the 50, 100, and 500-year flood plains is presented by reach in Table 2. There is approximately $1.1 billion dollars worth of damageable structures and contents. This excludes lands, bridges, utilities, and roads.

For residential structures, content values are fifty percent of the structure values and are not projected to grow beyond fifty percent of structure value. For commercial, industrial, and public and semi-public structures the value of contents were based on information gathered from personal interviews, field work, and other Sacramento District studies. Based upon past district studies, these content percentages are considered to be appropriate for the Westside Tributaries study area due to similar construction and building types.

Future Growth and Development

This analysis does not include future growth and development.

FLOOD DAMAGE EVALUATION

Based on data presented in the preceding paragraphs, flood damages were computed by determining relationships between damageable property and depths, flows, and frequencies of flooding. The following will discuss these relationships at greater length.

Types of Damages

The principal types of flood damages considered in this analysis are those physical damages and costs and losses that are caused by inundation. Physical losses include all structures and contents in the seven land use categories shown earlier as Residential, Multi-Residential, Mobile Homes, Farmsteads, Commercial, Industrial, and Public & Semi-Public. The content damages include furnishings, equipment and fixtures, raw materials, goods in production and finished goods. Other physical losses include automobile damages, agricultural damages, and damages to roads, bridges, and utilities.

Damage/Benefit Categories

1) Residential, Multi-Residential, Farm Houses, and Mobile Home losses include content, structure, yard area damages, and clean up.

2) Farm Structures losses include damages to farm houses and farm buildings

TABLE 2

TOTAL VALUE OF DAMAGEABLE PROPERTY BY REACH
(1993 PRICES)

REACH 1	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL STRUCTURE	$0	$0	$0
RESIDENTIAL CONTENT	$0	$0	$0
MULTI-RESIDENTIAL STRUCTURE	$0	$0	$0
MULTI-RESIDENTIAL CONTENT	$0	$0	$0
MOBILE HOME STRUCTURE	$0	$0	$0
MOBILE HOME CONTENT	$0	$0	$0
FARMSTEAD	$7,764,000	$7,764,000	$7,764,000
COMMERCIAL	$131,000	$131,000	$131,000
INDUSTRIAL	$0	$0	$0
PUBLIC	$0	$0	$0
TOTALS	$7,895,000	$7,895,000	$7,895,000

REACH 2	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL STRUCTURE	$6,820,000	$6,820,000	$6,820,000
RESIDENTIAL CONTENT	$3,410,000	$3,410,000	$3,410,000
MULTI-RESIDENTIAL STRUCTURE	$565,000	$565,000	$565,000
MULTI-RESIDENTIAL CONTENT	$282,000	$282,000	$282,000
MOBILE HOME STRUCTURE	$2,668,000	$2,668,000	$2,668,000
MOBILE HOME CONTENT	$1,334,000	$1,334,000	$1,334,000
FARMSTEAD	$1,608,000	$1,608,000	$1,608,000
COMMERCIAL	$536,000	$536,000	$536,000
INDUSTRIAL	$0	$0	$0
PUBLIC	$842,000	$842,000	$842,000
TOTALS	$18,065,000	$18,065,000	$18,065,000

REACH 3	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL STRUCTURE	$0	$0	$0
RESIDENTIAL CONTENT	$0	$0	$0
MULTI-RESIDENTIAL STRUCTURE	$0	$0	$0
MULTI-RESIDENTIAL CONTENT	$0	$0	$0
MOBILE HOME STRUCTURE	$0	$0	$0
MOBILE HOME CONTENT	$0	$0	$0
FARMSTEAD	$5,586,000	$5,586,000	$5,586,000
COMMERCIAL	$0	$0	$0
INDUSTRIAL	$0	$0	$0
PUBLIC	$0	$0	$0
TOTALS	$5,586,000	$5,586,000	$5,586,000

REACH 4	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL STRUCTURE	$206,122,000	$206,122,000	$206,122,000
RESIDENTIAL CONTENT	$103,061,000	$103,061,000	$103,061,000
MULTI-RESIDENTIAL STRUCTURE	$25,335,000	$25,335,000	$25,335,000
MULTI-RESIDENTIAL CONTENT	$12,668,000	$12,668,000	$12,668,000
MOBILE HOME STRUCTURE	$676,000	$676,000	$676,000
MOBILE HOME CONTENT	$338,000	$338,000	$338,000
FARMSTEAD	$16,499,000	$16,499,000	$16,499,000
COMMERCIAL	$71,346,000	$71,346,000	$71,346,000
INDUSTRIAL	$538,428,000	$538,428,000	$538,428,000
PUBLIC	$61,580,000	$61,580,000	$61,580,000
TOTALS	$1,036,053,000	$1,036,053,000	$1,036,053,000

TABLE 2
(Continued)

TOTALS FOR REACHES 1-4

REACH 1-4	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL STRUCTURE	$212,942,000	$212,942,000	$212,942,000
RESIDENTIAL CONTENT	$106,471,000	$106,471,000	$106,471,000
MULTI-RESIDENTIAL STRUCTURE	$25,900,000	$25,900,000	$25,900,000
MULTI-RESIDENTIAL CONTENT	$12,950,000	$12,950,000	$12,950,000
MOBILE HOME STRUCTURE	$3,344,000	$3,344,000	$3,344,000
MOBILE HOME CONTENT	$1,672,000	$1,672,000	$1,672,000
FARMSTEAD	$31,457,000	$31,457,000	$31,457,000
COMMERCIAL	$72,013,000	$72,013,000	$72,013,000
INDUSTRIAL	$538,428,000	$538,428,000	$538,428,000
PUBLIC	$62,422,000	$62,422,000	$62,422,000
TOTALS	$1,067,599,000	$1,067,599,000	$1,067,599,000

(barns, sheds) and their contents.

3) Commercial & Industrial losses include structure, raw materials, inventory, fixture, equipment, parking area damages, and clean up. No business loss benefits were considered appropriate for this analysis.

4) Public and Semi-Public losses include structure and content, as well as damages to roads, bridges, railroads, municipal water systems, utilities, churches, and public parking lots.

5) Agriculture losses include crop and non-crop damages. Non-crop damages would include damages to irrigation pumps and ditches and the costs incurred for the removal of silt and debris and land releveling.

6) Auto damages are those incurred by vehicles when owners do not have the opportunity to remove them from a flood hazard area.

7) Emergency costs are incurred during flooding for evacuation, reoccupation, and for temporary housing of flood plain inhabitants. Intangible damages such as loss of life and impaired health and living conditions cannot be evaluated in monetary terms and hence are not included in this damage analysis.

8) Detours occur when the inundation of a major highway, cause local and statewide travelers to adjust their routes. The extra monetary costs (gas and maintenance) and time costs (the salary loss of a driver) incurred may be eliminated once a project is in place.

After the number of physical units and the value associated with each unit was determined, damage susceptibility relationships were established by using the total value of each unit and comparing the associated depth of flooding. This process is discussed further in the next section.

Depth-Damage Relationships

The data collected in Table 2 was converted into damages mainly through the use of depth-damage relationships. These relationships describe the damages that would occur under different depths of flooding as a percentage of the total value of damageable property. Curves used for this part of the analysis were based primarily on the 1988 FEMA curves, and from curves by the Tennessee Valley Authority study prepared for the Department of Housing and Urban Development in December 1969. These curves were used for residential, commercial, industrial, and public & semi-public structures. In addition, farmstead damages were determined by using a depth damage curve developed by the Fort Worth District.

The curves presented in those earlier studies were examined to determine their relevance to structures in the study area. The curves were verified by comparing data gathered on other District studies (Morrison Creek, and Dry Creek California). The structures in the Yolo area are comparable to the structures in the above studies, therefore, the use of the same depth-damage curves proves to be prudent..

The depth-damage relationship derived by the Soil Conservation Service in 1983 for the Lower Silver Creek Watershed was used to estimate damages to automobiles. Auto damages were based on an estimate of the total number of automobiles in each flood plain hazard zone. Based on discussions with insurance companies it was determined that the typical household had 1.7 automobiles. The total number of automobiles in the flood plain was estimated by multiplying 1.7 by the number of households. It was assumed that 50 percent of the automobiles would be damaged during a flood event. The estimated number of cars was multiplied by the average value of an automobile ($6,000) to determine the value of all automobiles in the flood plain.

Some land use categories, such as emergency cost and detour costs, do not have depth-damage curves. Emergency costs were based upon the amount of people affected by the flood and the estimated amount of time it would take before reentry into the home was possible. The detour benefit was determined by estimating the net difference in mileage and time when driving the normal route and the detour. Rerouting of Interstate 5 traffic was the only detour benefit estimated for this analysis.

Agriculture crop damage determination involves a different methodology than other damages categories. For these damages, depths, and duration are both considered when estimating the damage that would occur to a particular crop during a particular month. Monthly damages are dependent on several variables: production costs expended at the time that crop damage may occur, the possibility that flooding destroys the crop, and consideration of whether an individual has an opportunity to replant the same crop or a replacement crop. Historical damages were also considered in the determination of agricultural damages and losses. Also estimated are damages to irrigation systems such as silt and debris removal and land releveling.

Average Annual Damages

a. Without Project

Average annual damages are the expected value of flood damages for a given economic condition and point in time. They are determined by weighing the estimated damages from varying degrees of flooding by their probability of occurrence and may be approximated by measuring the area under the damage-frequency curve using standard mathematical integration procedures.

Three flood plains (500, 100, and 50-year) were examined for this study. The total monetary losses for all reaches due to a 500-year flood would be almost $205 million dollars; while losses for a 100-year and 50-year flood would be about $186 million and slightly more

than $139 million dollars respectively. See Table 3 for reach totals.

Table 4-Reach 1 through Reach 4 shows the average annual damages without the proposed project for the present year, the base year, and annually throughout the study period. Average annual equivalent damages for the period 2000-2100 were estimated on the basis of an 8 percent interest level and October 1993 prices, using standard discounting procedures.

b. With Project Conditions

The average annual damages under without project conditions would also occur under project conditions, since residual damages are the average annual damages remaining under the "with project" condition. Under project conditions, the flow-damage relationship is the same, while the frequency-damage relationship changes due to an adjustment in the flow-frequency curve. In other words, damages are the same for both without project conditions for any given flow in a flooded area. The flow is redefined, however, and becomes a less frequent event under project conditions.

Probable average annual damages for the without and with project alternatives were estimated for the period (2000-2100) using standard discounting procedures, an 8 percent interest rate, and October 1993 prices. See Tables 5 for the reach benefit summaries.

BENEFIT EVALUATION

Inundation reduction benefits were estimated by evaluating damages for four alternatives. The flood damage reduction benefits for this project is the difference between the equivalent average annual flood losses without the project and the residual average annual losses (damages) with the project. All economic benefits have been developed in accordance with ER-1105-2-100.

ADVANCE REPLACEMENT TO BRIDGES

The project involves replacement of the Southern Pacific Railroad Bridge, Cacheville Road Bridge, and the Highway 113 Bridge. The Southern Pacific Railroad Bridge was constructed before 1914 and has 0 estimated remaining useful years of life. The expected life of the replacement bridge is 50 years. The total cost of the new bridge, $2,758,250 is included in the first cost of the project. A credit for extension, $225,500 annually, is included in the benefits. The Cacheville Road Bridge was constructed before 1914 and has a remaining useful life of 0 years. The life of the replacement bridge is 50 years. The total first cost of the new bridge is $1,238,010 and the credit for the extension is $101,200 annually. Lastly, the Highway 113 Bridge was constructed between 1970-1980 and has a remaining useful life of 25 years. The life of the replacement bridge is 50 years and extends the life of the bridge service 25 years. The total cost including the first cost of the project is $1,664,680 and annually the credit for the extension is $17,300. The project results in the advance replacement of bridges benefits totalling $344,000 annually.

TABLE 3 - REACH 1

EXISTING DAMAGE FOR
THE VARIOUS FLOOD PLAINS
1993 PRICES
($1,000)

REACH 1	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL	0	0	0
MULTI-RESIDENTIAL	0	0	0
FARMSTEAD	6	6	6
MOBILE HOMES	0	0	0
COMMERICAL	3	3	3
INDUSTRIAL	0	0	0
PUBLIC	0	0	0
AGRICULTURE	411	411	411
AUTOMOBILES	2	2	2
EMERGENCY	30	18	15
ROADS	75	75	75
TOTALS	527	515	512

NON-DAMAGING FREQUENCY: PNP= 5-YR AND PFP= 17-YR

TABLE 3 - REACH 2

EXISTING DAMAGE FOR
THE VARIOUS FLOOD PLAINS
1993 PRICES
($1,000)

REACH 2	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL	1,969	1,969	1,969
MULTI-RESIDENTIAL	102	102	102
FARMSTEAD	148	148	148
MOBILE HOMES	901	901	901
COMMERICAL	83	83	83
INDUSTRIAL	0	0	0
PUBLIC	121	121	121
AGRICULTURE	54	54	54
AUTOMOBILES	330	330	330
EMERGENCY	374	249	125
ROADS	52	52	52
TOTALS	4,134	4,009	3,885

NON-DAMAGING FREQUENCY: PNP= 9-YR AND PFP= 17-YR

TABLE 3 - REACH 3

EXISTING DAMAGE FOR
THE VARIOUS FLOOD PLAINS
1993 PRICES
($1,000)

REACH 3	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL	0	0	0
MULTI-RESIDENTIAL	0	0	0
FARMSTEAD	61	61	61
MOBILE HOMES	0	0	0
COMMERICAL	0	0	0
INDUSTRIAL	0	0	0
PUBLIC	0	0	0
AGRICULTURE	111	111	111
AUTOMOBILES	13	13	13
EMERGENCY	32	20	12
ROADS	43	43	43
TOTALS	260	248	240

NON-DAMAGING FREQUENCY: PNP= 3-YR AND PFP= 11-YR

TABLE 3 - REACH 4

EXISTING DAMAGE FOR
THE VARIOUS FLOOD PLAINS
1993 PRICES
($1,000)

REACH 4	500-YEAR	100-YEAR	50-YEAR
RESIDENTIAL	53,376	53,301	37,410
MULTI-RESIDENTIAL	5,652	5,094	5,094
FARMSTEAD	1,525	488	471
MOBILE HOMES	405	183	183
COMMERICAL	15,318	13,100	12,917
INDUSTRIAL	98,190	89,794	60,961
PUBLIC	8,300	5,703	5,703
AGRICULTURE	1,789	1,789	1,789
AUTOMOBILES	6,049	5,501	5,431
EMERGENCY	7,884	5,197	2,633
ROADS	1,046	968	954
DETOUR	501	501	501
TOTALS	200,035	181,619	134,047

NON-DAMAGING FREQUENCY: PNP= 6-YR AND PFP= 14-YR

TABLE 3 - SUMMARY

EXISTING DAMAGE FOR THE VARIOUS FLOOD PLAINS 1993 PRICES ($1,000)

REACH	500-YEAR	100-YEAR	50-YEAR	NON-DAMAGING FREQUENCY PNP	PFP
1	$527	$515	$512	5-YR	17-YR
2	$4,134	$4,009	$3,885	9-YR	17-YR
3	$260	$248	$240	3-YR	11-YR
4	$200,035	$181,619	$134,047	6-YR	14-YR
TOTAL	$204,956	$186,391	$138,684		

TABLE 4 - REACH 1

AVERAGE ANNUAL EQUIVALENT
DAMAGES AND BENEFITS
(1993 PRICES, 2000-2100 @ 8.0 % INTEREST RATE)
(IN $1,000)

	Without Project			100-YEAR				200-YEAR			
				LEVEE		CHANNEL		LEVEE		CHANNEL	
REACH 1	PNP	PFP	Average Damages	Residual Damages	BENEFITS	Residual Damages	BENEFITS	Residual Damages	BENEFITS	Residual Damages	BENEFITS
RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MULTI-RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MOBILE HOMES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FARMSTEAD	0.5	0.2	0.4	0.1	0.3	0.0	0.4	0.0	0.4	0.0	0.4
COMMERCIAL	0.3	0.1	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUBLIC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AGRICULTURE	33.9	15.1	24.5	4.1	20.4	1.4	23.1	2.0	22.5	0.6	23.9
AUTOMOBILE	0.2	0.1	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2
EMERGENCY	1.1	0.5	0.8	0.2	0.6	0.0	0.8	0.1	0.7	0.0	0.8
ROADS	6.1	2.7	4.4	0.7	3.7	0.3	4.1	0.4	4.0	0.1	4.3
TOTAL	42.1	18.7	30.5	5.1	25.4	1.7	28.8	2.5	28.0	0.7	29.8

TABLE 4 - REACH 2

AVERAGE ANNUAL EQUIVALENT
DAMAGES AND BENEFITS
(1993 PRICES, 2000-2100 @ 8.0 % INTEREST RATE)
(IN $1,000)

	Without Project			100-YEAR				200-YEAR			
				LEVEE		CHANNEL		LEVEE		CHANNEL	
REACH 2	PNP	PFP	Average Damages	Residual Damages	BENEFITS	Residual Damages	BENEFITS	Residual Damages	BENEFITS	Residual Damages	BENEFITS
RESIDENTIAL	120.2	72.2	96.2	19.5	76.7	6.8	89.4	9.7	86.5	2.9	93.3
MULTI-RESIDENTIAL	6.3	3.8	5.1	1.0	4.1	0.3	4.8	0.5	4.6	0.2	4.9
MOBILE HOMES	54.9	33.0	44.0	9.0	35.0	3.1	40.9	4.5	39.5	1.3	42.7
FARMSTEAD	9.0	5.4	7.2	1.5	5.7	0.5	6.7	0.7	6.5	0.2	7.0
COMMERCIAL	5.1	3.1	4.1	0.8	3.3	0.3	3.8	0.4	3.7	0.1	4.0
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUBLIC	7.4	4.4	5.9	1.2	4.7	0.4	5.5	0.6	5.3	0.2	5.7
AGRICULTURE	3.3	2.0	2.7	0.5	2.2	0.2	2.5	0.3	2.4	0.1	2.6
AUTOMOBILE	20.1	12.1	16.1	3.3	12.8	1.1	15.0	1.6	14.5	0.5	15.6
EMERGENCY	10.3	7.2	8.8	3.3	5.5	0.4	8.4	1.8	7.0	0.2	8.6
ROADS	3.2	1.9	2.6	0.5	2.1	0.2	2.4	0.3	2.3	0.1	2.5
TOTAL	239.8	145.1	192.7	40.6	152.1	13.3	179.4	20.4	172.3	5.8	186.9

TABLE 4 - REACH 3

AVERAGE ANNUAL EQUIVALENT
DAMAGES AND BENEFITS
(1993 PRICES, 2000-2100 @ 8.0 % INTEREST RATE)
(IN $1,000)

	Without Project			100-YEAR				200-YEAR			
				LEVEE		CHANNEL		LEVEE		CHANNEL	
REACH 3	PNP	PFP	Average Damages	Residual Damages	BENEFITS	Residual Damages	BENEFITS	Residual Damages	BENEFITS	Residual Damages	BENEFITS
RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MULTI-RESIDENTIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MOBILE HOMES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FARMSTEAD	7.4	3.0	5.2	0.6	4.6	0.2	5.0	0.3	4.9	0.1	5.1
COMMERCIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INDUSTRIAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUBLIC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AGRICULTURE	13.5	5.4	9.5	1.1	8.4	0.3	9.2	0.5	9.0	0.1	9.4
AUTOMOBILE	1.6	0.6	1.1	0.1	1.0	0.0	1.1	0.1	1.0	0.0	1.1
EMERGENCY	1.6	0.8	1.2	0.3	0.9	0.0	1.2	0.2	1.0	0.0	1.2
ROADS	5.2	2.1	3.7	0.4	3.3	0.1	3.6	0.2	3.5	0.1	3.6
TOTAL	29.3	11.9	20.7	2.5	18.2	0.6	20.1	1.3	19.4	0.3	20.4

TABLE 4 - REACH 4

AVERAGE ANNUAL EQUIVALENT DAMAGES AND BENEFITS (1993 PRICES, 2000-2100 @ 8.0 % INTEREST RATE) (IN $1,000)

	Without Project		100-YEAR				200-YEAR			
			LEVEE		CHANNEL		LEVEE		CHANNEL	
REACH 4	PNP	PFP	Average Damages	Residual Damages	BENEFITS	Residual Damages	BENEFITS	Residual Damages	BENEFITS	Residual Damages	BENEFITS
RESIDENTIAL	4,388.3	2,161.4	3,274.9	541.7	2,733.2	201.4	3,073.5	275.1	2,999.8	101.6	3,173.3
MULTI-RESIDENTIAL	386.3	209.3	297.8	55.0	242.8	18.7	279.1	28.7	269.1	8.1	289.7
MOBILE HOMES	15.1	8.7	11.9	3.2	8.7	0.6	11.3	1.9	10.0	0.3	11.6
FARMSTEAD	41.7	25.3	33.5	10.9	22.6	1.7	31.8	7.0	26.5	0.7	32.8
COMMERCIAL	987.1	538.1	762.6	145.9	616.7	47.6	715.0	77.2	685.4	20.5	742.1
INDUSTRIAL	5,071.7	2,952.7	4,012.2	960.5	3,051.7	224.4	3,787.8	499.5	3,512.7	96.6	3,915.6
PUBLIC	443.9	245.7	344.8	72.9	271.9	21.0	323.8	40.7	304.1	9.0	335.8
AGRICULTURE	134.2	72.0	103.1	17.8	85.3	6.6	96.5	8.9	94.2	2.8	100.3
AUTOMOBILE	412.7	223.9	318.3	59.0	259.3	20.0	298.3	30.7	287.6	8.6	309.7
EMERGENCY	252.6	161.1	206.9	68.3	138.6	9.7	197.2	38.5	168.4	4.2	202.7
ROADS	72.4	39.3	55.9	10.3	45.6	3.5	52.4	5.3	50.6	1.5	54.4
DETOUR	37.6	20.2	28.9	5.0	23.9	1.8	27.1	2.5	26.4	0.8	28.1
TOTAL	12,243.6	6,657.7	9,450.8	1,950.5	7,500.3	557.0	8,893.8	1,016.0	8,434.8	254.7	9,196.1

TABLE 5

TOTAL AVERAGE ANNUAL EQUIVALENT
DAMAGES AND BENEFITS
(1993 PRICES, 2000-2100 @ 8.0 % INTEREST RATE)
(IN $1,000)

	Without Project			100-YEAR				200-YEAR			
				LEVEE		CHANNEL		LEVEE		CHANNEL	
REACH	PNP	PFP	Average Damages	Residual Damages	BENEFITS	Residual Damages	BENEFITS	Residual Damages	BENEFITS	Residual Damages	BENEFITS
1	42.1	18.7	30.5	5.1	25.4	1.7	28.8	2.5	28.0	0.7	29.8
2	239.8	145.1	192.7	40.6	152.1	13.3	179.4	20.4	172.3	5.8	186.9
3	29.3	11.9	20.7	2.5	18.2	0.6	20.1	1.3	19.4	0.3	20.4
4	12,243.6	6,657.7	9,450.8	1,950.5	7,500.3	557.0	8,893.8	1,016.0	8,434.8	254.7	9,196.1
TOTAL WITHOUT PROJECT DAMAGES	$12,554.8	$6,833.4	$9,694.7	TOTAL RESIDUAL	$1,998.7		$572.6		$1,040.2		$261.5	
				TOTAL INUNDATION REDUCTION BENEFITS*		$7,696.0		$9,122.1		$8,654.5		$9,433.2
				ADVANCE REPLACEMENT OF BRIDGE BENEFITS		$344.0		$344.0		$344.0		$344.0
				TOTAL FLOOD CONTROL BENEFITS		$8,040.0		$9,466.1		$8,998.5		$9,777.2

*This does not include future growth.

A summary of the residual damages and inundation reduction benefits are presented in Tables 5 for each reach and the total.

APPENDIX F

PERTINENT CORRESPONDENCE

County of Yolo

625 Court Street, Room 204 Woodland, California 95695 (916) 666-8195

First District — Clark H. Cameron
Second District — Helen Thomson
Third District — George P. DeMars
Fourth Destrict — Betsy A. Marchand
Fifth District — Cowles Mast
Clerk of the Board — Paula M. Cooper

BOARD OF SUPERVISORS

November 7, 1991

Colonel Laurence R. Sadoff
U.S. Army Corps of Engineers
1325 "J" Street
Sacramento, California 95814-2922

Dear Colonel Sadoff:

Subject: Reconnaissance Study -- Flooding of Westside Tributaries to Yolo Bypass

Yolo County requests that the U.S. Army Corps of Engineers (Corps) undertake a reconnaissance study of flooding from westside tributaries to the Yolo Bypass. Such a study should evaluate alternatives to reduce the flood risk to the cities of Woodland and Davis, and other communities near Cache Creek, Putah Creek, and other westside drainage. Recent findings from other Corps studies combined with information from historic flood events indicate a significant potential for flooding of these communities.

Our understanding is that the Corps' ongoing Yolo Bypass Reconnaissance Investigation is concentrating on solutions to potential flooding problems from flows in the Yolo Bypass. The new study should focus on flooding from the upstream reaches of the westside tributaries to their inflows at the Yolo Bypass.

The County desires to be certain that both existing and future development in the area is safe from flooding from the westside tributaries. The County understands that if the requested reconnaissance study identifies a project warranting further action, the next step will be feasibility study and, at present, federal policy requires a 50 percent local cost-sharing commitment.

The County appreciates the attention that you and your staff have given to these issues, and your willingness to meet and discuss them with us. The Yolo County staff looks forward to assisting you in carrying out this project.

Sincerely,

Betsy A. Marchand

Betsy Marchand, Vice-Chair

Congressman Vic Fazio
City of Woodland
City of Davis
Yolo County Flood Control & Water Conservation District
State Reclamation Board
Senator Johnston
Senator Leslie
Assemblywoman Hansen
Assemblyman Hannigan

County of Yolo

625 Court Street, Room 204 Woodland, California 95695 (916) 666-8195

BOARD OF SUPERVISORS

First District — Michael McGowan
Second District — Helen Thomson
Third District — George P. DeMars
Fourth District — Betsy A. Marchand
Fifth District — Frank Sieferman
Clerk of the Board — Paula M. Cooper

June 21, 1994

Colonel John N. Reese, District Engineer
Sacramento District, Corps of Engineers
Department of the Army
1325 J Street
Sacramento, CA 95814-2922

Subject: Westside Tributaries to the Yolo Bypass

Dear Colonel Reese:

This is to confirm the intent of the County of Yolo to participate as a local sponsor for the feasibility study of the Westside Tributaries to the Yolo Bypass

The Sacramento District of the Corps has completed a draft Reconnaissance Report of these tributaries, and has concluded that a serious flood threat exists to the unincorporated town of Yolo and the city of Woodland. About 25 square miles in the unincorporated area of Yolo County are subject to flooding from an overflowing Cache Creek alone. The report has identified two feasible flood control plans that would increase the level of flood protection. Other alternatives should also be studied.

It is our intent to participate with the Corps on the feasibility phase of this study. Our sponsorship is subject to refining the scope of work for the study, the determination of study costs and financial participants, and the negotiation of a suitable feasibility cost-sharing agreement. We understand that this letter of intent is not a binding commitment by the County to provide funds.

We appreciate the opportunity to work with the Corps, and we look forward to the beginning of the feasibility study of the Westside Tributaries.

Sincerely,

Michael McGowan, Chair
Yolo County Board of Supervisors

City of Woodland

CITY COUNCIL 300 FIRST STREET WOODLAND, CALIFORNIA 95695 (916) 661-5800
FAX (916) 661-5844

Gary Sandy, Mayor
Elaine Rominger, Vice-Mayor
David M. Flory, Council Member
Jack Slaven, Council Member
Steve E. Borchard, Council Member

June 8, 1994

Colonel John N. Reese, District Engineer
Sacramento District, Corp of Engineers
Department of the Army
1325 J Street
Sacramento, CA 95814-2922

SUBJECT: Westside Tributaries to Yolo Bypass - Yolo County, CA

Dear Colonel Reese:

This letter will serve to convey the intention of the City of Woodland to be one of the non-Federal sponsors on the Westside Tributaries to Yolo Bypass feasibility study.

The Corp's Planning Division is currently completing the reconnaissance report on the Westside Tributaries to Yolo Bypass which, among other issues, outlines concerns about flood protection along Cache Creek which could lead to significant property damage within portions of our community. The City's interest is concentrated primarily on these concerns. The report indicates a Federal interest exists in a proposed effort to provide improvements to remedy these concerns.

The City understands that a non-Federal sponsor or sponsors is needed in order to proceed into the feasibility study phase. We also understand that the non-Federal sponsor(s) will be responsible for 50% of the estimated $2-3 million feasibility study cost. The non-Federal share can be provided entirely in cash, or up to 50% of the non-Federal share can be provided as in-kind services. The non-Federal share that is funded in cash is normally required to be provided in advance on a quarterly basis.

The scope of the feasibility study and the form of cost sharing among all sponsors needs to be negotiated and included in a Feasibility Cost Sharing Agreement(FCSA). It is understood that the scope of the feasibility study can be

expanded to include structural and non-structural alternatives other than those recommended in the reconnaissance report. Please be advised that the City of Woodland will need to seek the financial support of other agencies prior to entering into the FCSA. The City further understands that neither this letter of intent nor the subsequent FCSA commits the City of Woodland to participation in the preconstruction engineering and design phase, or the construction phase of the project.

Based on the foregoing, the City is willing to be one of the non-Federal sponsors for the feasibility study and to negotiate the FCSA with the Corp of Engineers and other non-Federal sponsors.

Should you have any questions about this please contact me or City Manager Kris Kristensen at (916) 661-5800 at your convenience.

Sincerely,

Gary Sandy
Mayor

cc
City Council
County of Yolo Board of Supervisors
Congressman Vic Fazio
Assemblyman Tom Hannigan

8 JUNE 1994

MEMORANDUM FOR FILE

SUBJECT: PEAK FLOW 27 JAN 1983 FOR CACHE CREEK AT YOLO

1. There have been several discrepancies as what was the peak flow that was measured at the USGS gaging station for Cache Creek at Yolo on the date of 27 Jan 1983. This has been brought to the attention of the U.S. Army Corps of Engineers at several public meetings for the Westside Tributaries Reconnaissance study.

2. A letter addressed to George Wedell, (former Engineering Division Chief), and dated February 1983 from the USGS had stated that the measured peak flow was 46,000 cfs. A value of 44,560 cfs was published in the Hydrology Review Report for Cache Creek Basin, 1985 by the Corps, Sacramento District, Hydrology Section.

3. The flow was calculated by measuring the stage of the creek and extrapolating the flow from a rating curve for the gage. It appeared to the USGS field group that the value was too high and it was discovered that backwater effects were not taken into account from water flowing over the Sacramento Weir into the Yolo Bypass. This could affect the stage for Cache Creek at Yolo since the creek also flows into the Yolo Bypass. An adjustment would have to be made to the rating curve to account for backwater effects and was not originally done. The USGS made the adjustment and the peak flow was found to be 33,000 cfs. This is the number published in the USGS Water Supply Paper for the water year 1983.

Chan Modini
Hydraulic Engineer,
Hydrology Section

cc:
Planning Div
Sacramento Basin Br.

COPY COPY COPY

Department of the Army
U.S. Army Engineer District, Sacramento
Corps of Engineers
650 Capitol Mall
Sacramento, California 95814

February 10, 1983

SPKED-T

Mr. Gail H. Winton
Yolo Engineers & Surveyors, Inc.
P O Box 1364
Woodland, California 95695

Dear Mr. Winton:

The flow values contained in the following paragraphs are in response to the questions you asked in your February 4, 1983 letter concerning the storm that occurred in the Woodland area on January 26, 1983.

We were informed by the United States Geological Survey that a peak flow of 33,000 cfs was recorded at the Yolo gage on Cache Creek at 7:15 a.m. on the morning of January 27, 1983. The stage reading for that peak was 83.75 feet (NGVD).

The 100-year peak flow, based on 81 years of data (1902 to present) at the Yolo gage is 46,000 cfs.

If you have any questions, please call Mr. Herb Hereth, Chief, Hydrology Section, (916) 440-2517.

Sincerely,

George C. Weddell
Chief, Engineering Division

APPENDIX G

DRAFT FEASIBILITY COST-SHARING AGREEMENT

AGREEMENT
BETWEEN THE DEPARTMENT OF THE ARMY
AND
THE CITY OF WOODLAND/YOLO COUNTY
FOR THE WESTSIDE TRIBUTARIES TO YOLO BYPASS, CALIFORNIA

THIS AGREEMENT is entered into this _____ day, of _____, 19____, by and between the Department of the Army (hereinafter the "Government"), represented by the District Engineer executing this Agreement, and the City of Woodland and Yolo County (hereinafter the "Sponsors"),

WITNESSETH, that

WHEREAS, the Congress has directed the Corps of Engineers in the Energy and Water Development Appropriations Act of 1993 (Public Law 102-377) to conduct "a reconnaissance study of flooding problems in the westside tributaries, Putah and Cache Creeks, of the Yolo Bypass" pursuant to the Flood Control Act of 1962 (Public Law 87-874); and

WHEREAS, the U.S. Army Corps of Engineers has conducted a reconnaissance study of Westside Tributaries to Yolo Bypass, California, pursuant to this authority, and has determined that further study in the nature of a "Feasibility Phase Study" (hereinafter the "Study") is required to fulfill the intent of the study authority and to assess the extent of the Federal interest in participating in a solution to the identified problem; and

WHEREAS, Section 105 of the Water Resources Development Act of 1986 (Public Law 99-662, as amended) specifies the cost sharing requirements applicable to the Study;

WHEREAS, the Sponsors have the authority and capability to furnish the cooperation hereinafter set forth and are willing to participate in study cost sharing and financing in accordance with the terms of this Agreement; and

WHEREAS, the Sponsors and the Government understand that entering into this Agreement in no way obligates either party to implement a project and that whether the Government supports a project authorization and budgets it for implementation depends upon, among other things, the outcome of the Study and whether the proposed solution is consistent with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies and with the budget priorities of the Administration;

NOW THEREFORE, the parties agree as follows:

ARTICLE I - DEFINITIONS

For the purposes of this Agreement:

A. The term "study costs" shall mean all disbursements by the Government pursuant to this Agreement, from Federal appropriations or from funds made available to the Government by the Sponsors, and all Negotiated Costs of work performed by the Sponsors pursuant to this Agreement. Study Costs shall include, but not be limited to: labor charges; direct costs; overhead expenses; supervision and administration costs; the costs of contracts with third parties, including termination or suspension charges; and any termination or suspension costs (ordinarily defined as those costs necessary to terminate ongoing contracts or obligations and to properly safeguard the work already accomplished) associated with this Agreement.

B. The term "study period" shall mean the time period for conducting the Study, commencing with the release to the U.S. Army Corps of Engineers, Sacramento District of initial Federal feasibility funds following the execution of this Agreement and ending when the Assistant Secretary of the Army (Civil Works) submits the feasibility report to the Office of Management and Budget (OMB) for review for consistency with the policies and programs of the President.

C. The term "IPMP" shall mean the Initial Project Management Plan, which is attached to this Agreement and which shall not be considered binding on either party and is subject to change by the Government.

D. The term "negotiated costs" shall mean the costs of in-kind services to be provided by the Sponsors in accordance with the IPMP.

E. The term "contracting officer" shall mean a representative of the Government with the authority to enter into, administer and/or terminate contracts and make related determinations and findings.

F. The term "fiscal year" shall mean one fiscal year of the Government. The Government fiscal year begins on October 1 and ends on September 30.

ARTICLE II - OBLIGATIONS OF PARTIES

A. The Government, using funds and in-kind services provided by the Sponsors and funds appropriated by the Congress of the United States, shall expeditiously prosecute and complete the Study, in accordance with the provisions of this Agreement and Federal laws, regulations, and policies.

B. In accordance with this Article and Article III of this Agreement, the Sponsors shall contribute cash and in-kind services equal to fifty (50) percent of total Study Costs. The Sponsors may, consistent with applicable law and regulations, contribute up to 25 percent of

total Study Costs through the provision of in-kind services. The in-kind services to be provided by the Sponsors, the estimated negotiated costs for those services, and the estimated schedule under which those services are to be provided are specified in the IPMP. Negotiated Costs shall be subject to an audit by the Government to determine reasonableness, allocability, and allowability.

C. The Sponsors understand that the schedule of work may require the Sponsors to provide cash or in-kind services at a rate that may result in the Sponsors temporarily diverging from the obligations concerning cash and in-kind services specified in paragraph B of this Article. Such temporary divergences shall be identified in the quarterly reports provided for in Article III.A. of this Agreement and shall not alter the obligations concerning costs and services specified in paragraph B of this Article or the obligations concerning payment specified in Article III of this Agreement.

D. If, upon the award of any contract or the performance of any in-house work for the Study by the Government or the Sponsors, cumulative financial obligations of the Government and the Sponsors would exceed 15 percent of the current estimate of total study cost, the Government and the Sponsors agree to defer award of that and all subsequent contracts, and performance of that and all subsequent in-house work, for the Study until the Government and the Sponsors agree to proceed, but in no event shall such a deferral exceed two years.

E. No Federal funds may be used to meet the Sponsors' share of Study Costs unless the Federal granting agency verifies in writing that the expenditure of such funds is expressly authorized by statute.

F. The award and management of any contract with a third party in furtherance of this Agreement which obligates Federal appropriations shall be exclusively within the control of the Government. The award and management of any contract by the Sponsors with a third party in furtherance of this Agreement which obligates funds of the Sponsors and does not obligate Federal appropriations shall be exclusively within the control of the Sponsors, but shall be subject to applicable Federal laws and regulations.

ARTICLE III - METHOD OF PAYMENT

A. The Government shall maintain current records of contributions provided by the parties, current projections of total Study Costs, and current projections of each party's share of total Study Costs. At least quarterly, the Government shall provide the Sponsors a report setting forth this information. Total Study Costs are currently estimated to be $2.2 million and the Sponsors' share of total Study Costs is currently estimated to be $1.1 million. In order to meet the Sponsors' cash payment requirements, the Sponsors must provide a cash contribution estimated to be $550,000. The dollar amounts set forth in this Article are based upon the Government's best estimates, which reflect projected costs, price-level changes, and anticipated inflation. Such cost estimates are subject to adjustment by the Government and

are not to be construed as the total financial responsibilities of the Government and the Sponsors.

B. The Sponsors shall provide their cash contribution required under Article II.B. of this Agreement in accordance with the following provisions:

1. For purposes of budget planning, the Government shall notify the Sponsors by July 1 of each year of the estimated funds that will be required from the Sponsors to meet the Sponsors' share of total Study Costs for the upcoming fiscal year.

2. No later than (60) calendar days prior to the scheduled date for the Government's issuance of the solicitation for the first contract for the Study or for the Government's anticipated first significant in-house expenditure for the Study, the Government shall notify the Sponsors in writing of the funds the Government determines to be required from the Sponsors to meet their required share of total Study Costs for the first fiscal year of the Study. No later than (30) calendar days thereafter, the Sponsors shall provide the Government the full amount of the required funds by delivering a check payable to "FAO, USAED, (Sacramento District)" to the contracting officer representing the Government.

3. For the second and subsequent fiscal years of the Study, the Government shall, no later than (60) calendar days prior to the beginning of the fiscal year, notify the Sponsors in writing of the funds the Government determines to be required from the Sponsors to meet their required share of total Study Costs for that fiscal year, taking into account any temporary divergences identified under Article II.C. of this Agreement. No later than (30) calendar days prior to the beginning of the fiscal year, the Sponsors shall make the full amount of the required funds available to the Government through the funding mechanism specified in paragraph B.2. of this Article.

4. The Government shall draw from the funds provided by the Sponsors such sums as the Government deems necessary to cover the Sponsors' share of contractual and in-house fiscal obligations attributable to the Study as they are incurred.

5. In the event the Government determines that the Sponsors must provide additional funds to meet their share of Study Costs, the Government shall so notify the Sponsors in writing. No later than 60 calendar days after receipt of such notice, the Sponsors shall make the full amount of the additional required funds available through the funding mechanism specified in paragraph B.2. of this Article.

C. Within ninety (90) days after the conclusion of the Study Period or termination of this Agreement, the Government shall conduct a final accounting of Study Costs, including disbursements by the Government of Federal funds, cash contributions by the Sponsors, and credits for the Negotiated Costs of the Sponsors, and shall furnish the Sponsors with the results of this accounting. Within thirty (30) days thereafter, the Government, subject to the availability of funds, shall reimburse the Sponsors for the excess, if any, of cash

contributions and credits given over their required share of total Study Costs, or the Sponsors shall provide the Government any cash contributions required for the Sponsors to meet their required share of total Study Costs.

ARTICLE IV - STUDY MANAGEMENT AND COORDINATION

A. To provide for consistent and effective communication, the Sponsors and the Government shall appoint named senior representatives to an Executive Committee. The Executive Committee will include the District Engineer, the Chief of Planning Division, and the Deputy District Engineer for Project Management. The Sponsors, along with primary technical advisors, will be equal partners with the Corps representatives on the Executive Committee. The District Engineer and his counterpart with the Sponsors will co-chair Executive Committee. Thereafter, the Executive Committee shall meet regularly until the end of the Study Period.

B. Until the end of the Study Period, the Executive Committee shall generally oversee the Study consistently with the IPMP.

C. The Executive Committee may make recommendations that it deems warranted to the Government on matters that it oversees, including suggestions to avoid potential sources of dispute. The Government in good faith shall consider such recommendations. The Government has the discretion to accept, reject, or modify the Executive Committee's recommendations.

D. The Executive Committee shall appoint representatives to serve on a Study Management Team. The Study Management Team shall keep the Executive Committee informed of the progress of the Study and of significant pending issues and actions, and shall prepare periodic reports on the progress of all work items identified in the IPMP.

ARTICLE V - DISPUTES

Before a party to this Agreement may bring suit in any court concerning an issue relating to this Agreement, the party must first seek in good faith to resolve the issue through negotiation or other forms of non-binding alternative dispute resolution mutually acceptable to the parties.

ARTICLE VI - MAINTENANCE OF RECORDS

A. Within 60 days of the effective date of this Agreement, the Government and the Sponsors shall develop procedures for keeping books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to this Agreement to the extent and in such detail as will properly reflect total Study Costs. These procedures shall incorporate, and apply as appropriate, the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to state and

local governments at 32 C.F.R. Section 33.20. The Government and the Sponsors shall maintain such books, records, documents, and other evidence in accordance with these procedures for a minimum of three years after completion of the Study and resolution of all relevant claims arising therefrom. To the extent permitted under applicable Federal laws and regulations, the Government and the Sponsors shall each allow the other to inspect such books, documents, records, and other evidence.

B. In accordance with 31 U.S.C. Section 7503, the Government may conduct audits in addition to any audit that the Sponsors are required to conduct under the Single Audit Act of 1984, 31 U.S.C. Sections 7501-7507. Any such Government audits shall be conducted in accordance with Government Auditing Standards and the cost principles in OMB Circular No. A-87 and other applicable cost principles and regulations. The costs of Government audits shall be included in total Study Costs and shared in accordance with the provisions of this Agreement.

ARTICLE VII - RELATIONSHIP OF PARTIES

The Government and the Sponsors act in independent capacities in the performance of their respective rights and obligations under this Agreement, and neither is to be considered the officer, agent, or employee of the other.

ARTICLE VIII - OFFICIALS NOT TO BENEFIT

No member of or delegate to the Congress, nor any resident commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom.

ARTICLE IX - FEDERAL AND STATE LAWS

In the exercise of the Sponsors' rights and obligations under this Agreement, the Sponsors agree to comply with all applicable Federal and State laws and regulations, including Section 601 of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) and Department of Defense Directive 5500.1 issued pursuant thereto and published in 32 C.F.R. Part 300, as well as Army Regulations 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army".

ARTICLE X - TERMINATION OR SUSPENSION

A. This Agreement shall terminate at the end of the Study Period; provided, that prior to such time and upon thirty (30) days written notice, either party may terminate or suspend this Agreement. In addition, the Government shall terminate this Agreement immediately upon any failure of the Sponsors to fulfill their obligations under Article III of this Agreement. In the event that either party elects to terminate this Agreement, both parties shall conclude their activities relating to the Study and proceed to a final accounting in accordance with

Article III.C. of this Agreement. Upon termination of this Agreement, all data and information generated as part of the Study shall be made available to both parties.

B. Any termination of this Agreement shall not relieve the parties of liability for any obligations previously incurred, including the costs of closing out or transferring any existing contracts.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement, which shall become effective upon the date it is signed by the District Engineer for the U.S. Army Corps of Engineers, Sacramento District.

DEPARTMENT OF THE ARMY

BY_____
Colonel, Corps of Engineers
District Engineer
Sacramento District

Sponsors

BY_____
Mayor, City of Woodland

BY_____
Chairperson, Yolo County
Board of Supervisors

Attachment - Initial Project Management Plan

APPENDIX H

INITIAL PROJECT MANAGEMENT PLAN

INITIAL PROJECT MANAGEMENT PLAN

WESTSIDE TRIBUTARIES TO YOLO BYPASS (YOLO COUNTY), CALIFORNIA

FEASIBILITY PHASE

WESTSIDE TRIBUTARIES TO YOLO BYPASS
(YOLO COUNTY), CALIFORNIA
FEASIBILITY PHASE

INITIAL PROJECT MANAGEMENT PLAN

Table of Contents

	Page
Scope of Study	H-1
Work Breakdown Structure	H-21
Study Schedule	H-25
Organizational Breakdown Structure	H-26
Responsibility Assignment Matrix	H-28

WESTSIDE TRIBUTARIES TO YOLO BYPASS (YOLO COUNTY), CALIFORNIA FEASIBILITY PHASE

SCOPE OF STUDY

1.0 PURPOSE

The purpose of this Initial Project Management Plan (IPMP) is to outline the program to conduct and manage the feasibility phase of the Westside Tributaries to Yolo Bypass (Yolo County), California, study. The IPMP is an integral part of the Feasibility Cost-Sharing Agreement (FCSA) and serves as the basis for assigning the feasibility study activities. The IPMP is flexible in achieving solutions to the flood control and associated water and environmental problems and needs along the westside tributaries. It identifies the task items, funding schedules, and cost estimates required in the feasibility phase of the Westside Tributaries study. In order to clarify cost-sharing responsibilities, the study obligations of the Corps of Engineers (Corps) and the non-Federal sponsors, the City of Woodland and Yolo County, will be identified in accordance with the Water Resources Development Act of 1986 (WRDA 1986).

2.0 SCOPE

The feasibility report and the accompanying environmental impact statement/environmental impact report (EIS/EIR) will be a complete decision document that presents the results of the feasibility studies. Flood threats exist to the City of Woodland and to the town of Yolo. Related problems include sedimentation problems in the study area associated with flooding. Other needs and opportunities are water supply, water conservation, and environmental restoration and mitigation. The feasibility report will provide a complete presentation of study results and findings, including those developed in the reconnaissance study; indicate compliance with applicable statues and policies; and provide a sound basis for the recommended solution. The feasibility study will identify the National Economic Development (NED) plan resulting from plan formulation activities outlined in the Corps' feasibility document. The NED plan will form the basis for cost sharing of any plan recommended for construction. Any recommended plan that deviates from the NED plan will be identified as the locally preferred plan (LLP).

3.0 DESCRIPTION OF THE STUDY AREA

The study area extends from the western levees of the Yolo Bypass into the eastern foothills of the Coast Range and includes parts of Yolo, Colusa, Solano, Napa, and Lake Counties. The area includes three sub-basins of the Sacramento River basin: Cache Creek, Willow Slough, and Putah Creek. The feasibility study will focus on flood protection and

environmental restoration needs within the Cache Creek basin. The primary communities in the study area include Woodland, Yolo, Madison, and Esparto.

4.0 NON-FEDERAL SUPPORTS

In a letter dated 9 June 1994 (see Appendix F), the City of Woodland indicated their intent to act as the non-Federal sponsors for the Westside Tributaries feasibility phase study.

5.0 STUDY AUTHORIZATION

In the Energy and Water Development Appropriations Act of 1993 (Public Law 102-377), Congress directed the Corps, under the authority of the Flood Control Act of 1962 (Public Law 87-874), to conduct a reconnaissance study of flooding problems along the westside tributaries of the Yolo Bypass.

6.0 FEASIBILITY PLAN FORMULATION

The feasibility plan formulation will focus on the flooding problems of Woodland and Yolo as indicated by the Westside Tributaries Reconnaissance Study. Work will consist of updating the alternatives formulated during the reconnaissance study, including setback levees and channel improvements along lower Cache Creek. The study reach along Cache Creek, downstream from Capay to the Cache Creek settling basin, is about 20 miles. Critical elements include an inventory of the baseline resource conditions along Cache Creek, including both detailed existing and historical conditions as follows: survey data, hydrology, hydraulics, flood plain, foundation and materials, design and cost estimates, real estate, structures, sedimentation, geomorphology, environmental analysis, cultural resources, economics, riparian and aquatic resources, environmental mitigation, environmental restoration, plan formulation, and project and study management. Also included will be an evaluation of impacts from gravel mining and operation and maintenance of the project levees and/channels. A detailed plan evaluation will be undertaken during this phase on all viable plans in order to determine the Federal interest. A comparison of alternatives based on associated costs and benefits will be made, and the NED plan will be identified.

7.0 REPORT PREPARATION

Initially, the Corps and non-Federal sponsors will prepare a draft feasibility report and EIS/EIR and distribute it for public review. Following the review and clearance of the report and EIS/EIR by non-Federal sponsors and higher authority, the feasibility report and EIS/EIR will be finalized. It will be complete with appendixes, which will provide details on coordination activities and engineering, real estate, plan formulation, environmental and economic studies, and a preliminary financing plan.

Comments received on the draft feasibility report and EIS/EIR will be addressed and revisions made as necessary to prepare the final report. The non-Federal sponsors will be

participating in any additional significant rewriting, documentation, analysis, or reformulation as a result of Washington-level review. A "review support" work item will cover expenditures for any such activities. The review support will be $50,000. Should costs be incurred beyond the review support, the FCSA will be modified to provide for 50-50 cost sharing of any additional costs. Any costs relating to the feasibility report that are incurred following completion of the feasibility phase, with the exception of review support activities, will be funded 100 percent by the Corps.

8.0 FEASIBILITY STUDY COORDINATION

8.1 Study Management Structure

The study will be managed by the following five groups, at the appropriate level, throughout all phases of the study.

- Headquarters US Army Corps of Engineers (HQUSACE) PRB
- South Pacific Division (CESPD) PRB
- Sacramento District (CESPK) PRB
- Executive Committee
- Study Management Team

The principal document that will be used for reporting to the Project Review Boards (PRB) and the Executive Committee will be the Project Executive Summary (PES) report, which is issued monthly.

The HQUSACE PRB will be chaired by the Director of Civil Works or designee and include the chiefs of the functional elements whose functions are integral to the Corps role in civil works projects. The HQUSACE PRB will facilitate resolution of major study issues, concerns, or problems through Corps channels and make recommendations to the Director of Civil Works, CESPD, and the non-Federal sponsors as part of intensive management. The HQUSACE PRB will also approve changes in major milestones and significant cost increases in accordance with Engineering Regulation (ER) 5-7-1, Project Management.

The CESPD PRB will be chaired by the Division Commander or designee and include the chiefs of the elements whose functions are integral to the role of the Division in civil works projects. The CESPD PRB will review monthly PES reports for compliance with the IPMP and provide comments to the Sacramento District. The CESPK PRB will facilitate resolution of, or elevate to the CESPD Commander or higher authority, the major issues raised during the study, monitor study contingencies and cost changes in the approved study cost estimate, and take appropriate action on Schedule and Cost Change Requests (SACCR) in accordance with ER 5-7-1. The non-Federal sponsors are encouraged to participate in the CESPK PRB.

8.2 Executive Committee and Study Management Team

The feasibility studies will be managed by an Executive Committee and a Study Management Team, as provided in the FCSA. The Executive Committee will oversee the overall management of the study. The Study Management Team will also ensure that the approved IPMP is followed, the study schedule and budget are maintained, and appropriate policies and guidelines are followed.

The Study Management Team will include the Corps planning manager, Corps project manager, study manager from the non-Federal sponsor, and other key study team members. The Study Management Team will oversee the studies to ensure the establishment of desired mutual roles, interests, and study objectives. The Study Management Team will implement the overall direction of the study provided by the Executive Management Committee to ensure that Corps policies and the breakdown of tasks in the IPMP are followed. In addition, the Study Management Team will make sure that the study schedule and budget are maintained, that sound technical judgement is followed, and that multi-disciplinary studies and decisions are made in accordance with applicable guidelines and policies. The Study Management Team will ensure that adequate input to the study process is received from the appropriate Federal, State, and local agencies, interested organizations, and individuals.

8.3 Quality Management Strategy

The goal of the quality management strategy is to achieve high quality products and output from the study. The measurement of quality will be made in terms of specific criteria. The criteria will be kept to the minimum to ensure quality products. Quality will be achieved through feedback reviews of technical reports, feasibility report, EIS/EIR, and technical appendixes throughout the study. Feedback will be conducted by study team meetings throughout the study.

Output from the study will consist of draft and final technical reports, feasibility report, EIS/EIR, and technical appendixes including engineering and real estate acquisition appendixes.

The quality of these products will be measured principally by the team members, in connection with checkpoint meetings. Team members will review draft office reports resulting from various tasks and provide comments during the team meetings. The reviews will be for completeness; conformance to Corps and sponsors regulations, laws, and guidance; accuracy; and thoroughness.

9.0 TASKS AND RESPONSIBILITIES

The Westside Tributaries feasibility study will evaluate flood control alternatives with the focus on formulation, analysis, and plan selection. The feasibility study will include the following study tasks: public involvement, environmental studies, hydrologic studies,

hydraulic studies, sediment engineering studies, study management, institutional studies, plan formulation, economic studies, design, survey and mapping, cost estimation, flood plain analyses, fish and wildlife studies, geotechnical studies, cultural resource studies, real estate studies, report preparation, and report review. Work order requests (WOR's) will be issued by the Corps study manager detailing specific study tasks, funding, milestones, and form and detail of the expected product.

Following is a description of the major feasibility study tasks and responsibilities to accomplish those tasks. At the completion of each task, the non-initiating agency may review the results of the task before it is considered complete. As referenced in the FCSA, Article I, the item "Negotiated Cost" is the fixed fee for a work item to be accomplished by the non-Federal sponsors as an in-kind service. The term "in-kind" is defined as those tasks completed by the non-Federal sponsors in substitution of a cash contribution. Technical studies performed by the non-Federal sponsors will be reviewed for conformance to Corps standards and study needs. The major study tasks and their expected costs are included in Table 1.

10.0 STUDY ACTIVITIES

10.1 Public Involvement

This task will be performed by the Corps and non-Federal sponsor. This task primarily consists of coordinating the study scope, results, and solutions with the public; conducting public meetings and workshops; and responding to public inquiries. The public meetings include a scoping workshop at the beginning of the study and a final meeting after the draft feasibility report and EIS/EIR are distributed for public review. Also included is preparation of a public involvement plan to guide public involvement activities throughout the study.

The Corps will prepare the notice of initiation of the feasibility study and notice of intent to prepare an EIS/EIR; prepare materials for public meetings; conduct the workshops and public meetings; prepare newsletters to keep interested parties informed; provide necessary local, State, and Federal coordination; and compile and maintain mailing lists. The Corps will also prepare the public involvement plan and documentation of the public meetings.

The non-Federal sponsors will arrange for obtaining a meeting place for public meetings, inviting the public, and printing and distributing the announcements.

10.2 Institutional Studies

This task will be performed by the Corps and the non-Federal sponsor. It consists primarily of determining the financial and legal arrangements required to implement the recommended plan, including methods of financing. The financial capability analysis will

examine the non-Federal sponsors' organizational, legal, and financial capability to undertake the required financial obligations for implementation of the project after it is authorized for construction by Congress.

The non-Federal sponsors will prepare a financing plan and an accompanying statement of financial capability. The financing plan should include a schedule of the sources and uses of local government income, current local indebtedness, operating expenses, expenditures, trends in assessed values, and other financial data. The statement of financial capability should provide evidence of the sponsors' authority to use the identified sources of income.

The Corps will prepare an assessment of the non-Federal sponsors' financial capability based on a review of the financial plan.

10.3 Social Studies

This task will be performed by the Corps. The social studies will determine the social environment of the study area and determine the social impacts which result from the various alternate plans and the NED plan. A detailed report which includes applicable information generated during the public meetings/workshops will be prepared.

10.4 Cultural Resources Studies

This task will be performed by the Corps. All studies will be performed in accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, 36 CFR 800 "Protection of Historic Properties," and Corps ER 1105-2-100.

In consultation with the State Historic Preservation Officer (SHPO), the Corps will conduct sufficient archival and field surveys to identify cultural sites within the study's Area of Potential Effect and evaluate the eligibility of all cultural sites for the National Register of Historic Places. A detailed report will be prepared which will describe all cultural resources within the Area of Potential Effect and assess the impacts of alternatives on these resources. The report will also describe the range of additional future preservation or mitigation efforts, if required, and the associated costs of these studies.

If project alternatives are found that will have an effect on sites eligible for the National Register, the Corps will proceed with further consultation with the SHPO and will give the Advisory Council on Historic Preservation (ACHP) and other interested parties an opportunity to comment. If necessary, the Corps may enter into a Memorandum of Agreement with the SHPO, ACHP, and non-Federal sponsors to stipulate ways to avoid or reduce the effects of project alternatives on cultural resources. Preservation or mitigation of cultural resources will be considered in more detail for the plan recommended for construction in any advanced planning for the project.

10.5 Environmental Studies

This task will be performed primarily by the Corps and assumes the preparation of an EIS/EIR.

The Corps will prepare the draft and final EIS/EIR and public notice. The EIS/EIR will evaluate the environmental effects of the alternative plans and will be coordinated with the Federal, State, local governments and agencies, and interested groups and individuals. Environmental study tasks include all activities required to comply with the National Environmental Protection Act (NEPA) and California Environmental Quality Act (CEQA). Activities include literature searches and review of existing reports and field surveys to establish environmental baseline conditions; identification of future "without-project" conditions; determination of impacts of the alternatives; coordination with the U.S. Fish and Wildlife Service (FWS); analysis of mitigation needs; development and preparation of all appropriate NEPA and CEQA documents; review of in-house reports; response to comments; and support to the study manager and others during the study phase.

The scope of the mitigation measures for fish and wildlife and other affected resources will be described. An incremental mitigation analysis will be completed, if required. An incremental cost analysis will be performed for all recommended mitigation plans. The purposes of the incremental cost analysis are to determine and show variations in costs and to identify and describe the least costly plan. Mitigation analysis will be presented in an analytical framework similar to other project benefits and costs so that rational decisions regarding mitigation can be made. The least costly mitigation plan that provides full mitigation of losses specified in the mitigation planning objective and is unconstrained except for required legal and technical constraints will always be identified and shown. Planning methods and data will be used to yield cost estimates with accuracy and reliability similar to other cost analysis components of the overall study. Any land required for mitigation will be identified. A plan will be developed for fish and wildlife resources mitigation. A monitoring plan will be developed, if required, to record the success of mitigation measures.

An air quality analysis will be performed to comply with 1990 Clean Air Act amendments, if required.

The cultural resources study will be included in the EIS/EIR.

Pursuant to the U.S. Fish and Wildlife Service Coordination Act, a Coordination Act Report (CAR) will be prepared by the FWS in coordination with the Corps.

A Section 404 (b) (1) evaluation of water quality impacts will be developed, if necessary, and coordinated with State and Federal water quality agencies to ensure that adequate consideration has been given to water quality and to acquire water quality certification or, if appropriate, an exemption.

Requirements of Section 7 of the Endangered Species Act will be completed during the feasibility study, including a biological assessment and formal consultation with the FWS, if necessary. Requirements of the State Endangered Species Act will be completed during the feasibility study.

Adherence with Executive Order 11988 for Flood Plain Management and other pertinent environmental statutes and regulations will be noted in the EIS/EIR.

Studies will be conducted to examine the possibility of protection and/or restoration along any stretches of channel which have been altered.

The non-Federal sponsors' task includes coordinating with the Corps on the preparation of an EIS/EIR that meets requirements of both Federal and State laws pursuant to NEPA and CEQA. The non-Federal sponsors will prepare tables and chapters that are required solely to satisfy CEQA for inclusion in the EIS/EIR.

Corps activities include coordination with the FWS and the State, in-house report review, response to comments, and support to the study manager and others during the study phase.

10.6 Economic Studies

This task will be performed by the Corps and the non-Federal sponsor. Corps tasks will include obtaining flood plain maps and gathering and compiling property and structure characteristics such as foundation heights, square footage, number of stories, usage, and type of construction for those structures located within the flood plains. The amount of flood-damageable property and their contents will be estimated through interviews and statistical sampling. Historical flood damage information will also be collected. Economic data will be presented in tables that display the number of structures, value of property, and benefits by property category.

Flood damages will be evaluated, and flood control benefits of the various alternatives and the selected plan will be determined. Essential hydrologic and hydraulic input to the flood damage analysis includes without- and with-project stage data. Existing conditions and future land use development projections will also be evaluated.

Once flood damages are estimated, the following benefit categories will be determined: inundation reduction benefits, location benefits, savings in flood proofing costs, advanced bridge replacement, transportation cost savings, emergency cost savings, and employment benefits. Other potential benefits associated with incidental purposes will also be examined. Benefits will be updated every 2 years. Future land use projections will be verified for accuracy in the analysis of the inundation reduction benefits.

A risk and uncertainty analysis will be done in order to help quantify uncertainties in the flood damage estimates, and a probability distribution will be developed for expected annual flood damages and flood reduction benefits associated with the various alternatives and the selected plan. The critical key variables that will be evaluated include structure first-floor elevation, structure values, and content values.

These studies will assist in measuring potential flood damages and flood control benefits when evaluating potential projects. An economics appendix will be provided for inclusion in the technical documentation for the feasibility study and will include development of benefits for each alternative. Tasks will include preparing materials, including text and plates, for inclusion in the appendix; assisting in plan formulation; reviewing in-house reports; responding to comments; and supporting the study manager and others during the study phase. This task also includes preparation of task and cost estimates for the Project Management Plan (PMP).

10.7 Surveys and Mapping - Flood Plain

This task will be performed jointly by the non-Federal sponsors and the Corps. The non-Federal sponsors will participate in surveying and mapping (aerial photography) the study area as part of their in-kind services. The task will include spot elevation surveys of the 25 square miles of flood plain area. Surveying will be initiated at the start of the feasibility study.

10.8 Surveying and Mapping - Channel

This task will be performed jointly by the Corps and the non-Federal sponsor. The surveying and mapping (aerial photography) will include the 16 miles of channel from Road 94B to the Cache Creek settling basin (including perimeter and training levees), a 2,000-foot width, and a scale of 1"=200'. This task includes taking eight cross sections per mile for about 10 miles of the channel from I-5 to the settling basin and surveying elevations and dimensions of existing bridges and other affected structures within the channel.

The survey and mapping data will be transferred in an electronic or hardware format coordinated between the Corps and the non-Federal sponsor. Arc Info and Intergraph compatible formats will be used as the data platform. Required mapping will be compiled in California State Plane coordinates, meet U.S. Bureau of the Budget's "United States National Map Accuracy Standards," and comply with standards and requirements of Design Manual 4-805-10, "Surveying and Mapping," dated December 1991. Final product of the survey and mapping data will include vellum copies of the formatted computerized Arc Info information and Intergraph files.

The Corps will closely coordinate and review all surveying methods and submittals by the non-Federal sponsor. The initial surveying effort will include reviewing existing surveys and maps of the study area from the Corps files and all local agencies. The final surveying

effort will be determined based on the selected plan and the adequacy of the existing survey data. River channel cross-sectional surveys will be made during the sediment transport studies.

10.9 Hydrology

This task will be performed primarily by the Corps with review and coordination by the non-Federal sponsor. A feasibility-level hydrology report will be prepared by the Corps. Study tasks include review of existing literature and data on hydrology of the study areas, field reconnaissance, verification of basic rainfall-runoff criteria by reconstitution, determination of with- and without-project discharge frequency values, interior flooding analysis, risk and uncertainty analysis, and documentation.

Verification of rainfall-runoff criteria by reconstitution will consist of gathering and processing coincident storm and flood data from available gages in the area and reconstructing the observed flood events. The results will be compared with current Corps criteria.

Documentation will consist of preparation of the office report complete with text, tables, maps, and plates. All review comments will be considered, and modifications to the office report will be completed.

Other Corps tasks include reviewing the draft feasibility report, providing technical support to the study manager, and providing input to the PMP.

10.10 Hydraulic Design

This task will be performed primarily by the Corps. The task includes all hydraulic analyses necessary for evaluation of alternatives and preparation of design and cost estimates for optimization studies and the development of the NED plan. Tasks will include establishing the criteria for each study task prior to design or modeling; reviewing and evaluating existing data and information on hydraulics in the study area channels; conducting field investigations; developing stage-discharge rating curves for use in the risk-base analysis; performing sedimentation and sediment routing studies, which will include infiltration testing that considers the impacts of sediment buildup over time; designing channels and culverts; determining the need for channel bed and/or bank protection; determining the need for new levees along Cache Creek; analyzing interior flood control; evaluating the potential for inducing flooding; and analyzing risk and uncertainty.

Hydraulic analyses using the HEC-2 and HEC-6 computer programs will also be conducted along Cache Creek to determine the sediment transport characteristics and behavior of the main channel. This task will include documentation of the results of the sediment transport study.

The Corps will prepare an appendix which will include text and plates that document the basis of hydraulic design of project features and cost estimates for the PMP.

The non-Federal sponsors and the Corps will review and coordinate the hydraulic studies. Coordination will include review of technical and operational criteria for the hydraulic features.

10.11 Flood Plain Studies

This task will be performed by the Corps. Regional Planning Branch will determine the without-project channel capacities and coordinate this without-project condition with Hydraulic Design and Hydrology Sections. Flood plain study tasks include use of present and future condition overflows for 10-, 50-, 100-, and 500-year flood frequencies to determine flood plain boundaries and depths of flooding for the project reach and overflow areas. The flood plains prepared during the reconnaissance phase will be reassessed for adequacy, and detailed feasibility-level flood plain studies will be developed for the area extending from the vicinity of Capay to the Cache Creek Settling Basin. This task also includes tables and plates to be included in the appendix; report review; response to comments; and support to the study manager and others during the study phase.

10.12 Foundations and Materials

This task will be primarily performed by the Corps. This effort will include a literature search of all previous geotechnical studies, including soils and engineering of the study area, field investigations, PNP/PFP profiles for existing project and non-project levees in the study area, sampling and laboratory testing, and preparation of a geotechnical office report appendix to the feasibility report. The type and extent of the drilling and the type of tests conducted will be determined by the project features.

10.13 Design

This task entails the preparation of feasibility quality design and cost estimates for the alternatives to be evaluated and final design and cost estimates for the NED plan. This includes preparation of a detailed basis of design that describes all aspects of the selected features. The report will include plans and profiles of embankments, hydraulic structure features, relocations, channel details, bridge crossings, and operation and maintenance requirements. This task also includes preparation of an engineering basis of design (BOD) that defines the various design features. The quality will be such that final design documents for the recommended plan can be prepared by adding additional detail to the BOD. Intergraph will be the data platform used for all design work, and all data will be compatible with the Arc Info format.

The BOD will be prepared primarily by the Corps. The BOD is a narrative report that documents all engineering studies, designs, and cost estimates that have been prepared.

This report, complete with maps, charts, and plates, will be an appendix to the feasibility report. The engineering focus will be to develop studies to the level necessary to prepare design and cost estimates for alternatives, optimization studies, and the NED plan. A baseline cost estimate will be developed which uses the Micro Computer Aided Cost Estimating System (MCACES). This MCACES cost estimate will be prepared for the NED plan and will be used for detailed studies during the subsequent pre construction, engineering, and design. The BOD will provide sufficient design layouts, analyses, and studies to establish basic features and elements. Adequate investigations will be done to evaluate esthetics and determine whether or not hazardous or toxic materials are present.

The Corps will develop the preliminary construction procedure, construction sequence, and water control plan for each step of the proposed plan. Construction equipment and production rates will be coordinated with Corps construction elements, who will also develop the estimated supervision and construction management costs. An operation and maintenance plan, including an inspection plan, will be developed for the project. Budgets and schedules for the preparation of the necessary operation and maintenance manual will be provided for inclusion into the PMP.

Using input from the non-Federal sponsors, the Corps will develop a sufficient level of design to define the appropriate level of risk associated with contingencies in the baseline cost estimate. The cost estimates will include real estate requirements. Mitigation and cultural preservation requirements will also be coordinated with Corps environmental elements and included in the baseline estimate.

This work effort by the Corps and the non-Federal sponsors will include support to the study manager in plan formulation throughout the feasibility report preparation, draft and final BOD, feasibility report reviews, preparation of response to comments, preparation of the PMP, and study conference attendance.

10.14 Cost Estimates

This task will be performed by the Corps. Feasibility-level baseline cost estimates will be developed for the selected plan. These estimates will be the total cost (Federal and non-Federal) of implementing the project, including construction costs, lands, easements, rights-of-way, relocations, disposal areas, mitigation, engineering and design, and construction management. Detailed first and annual cost estimates, including operation and maintenance, inspection plan, interest during construction, and replacement costs will be developed in the MCACES format for the recommended plan, in accordance with Engineering Circular (EC) 1110-2-538, Civil Works Projects Cost Estimates - Code of Accounts and EC 110-2-263, Civil Works Project Construction Cost Estimating. A narrative basis of cost estimate will be prepared and included as an appendix in the feasibility report.

10.15 Environmental Engineering

This task will be performed by the Corps. Hazardous, toxic, and radiological waste (HTRW) studies will be done in accordance with ER 1165-2-132, Hazardous, Toxic, and Radioactive Waste (HTRW) Guidance for Civil Works Projects. Work will include field reconnaissance of the study area, review of the literature, coordination with Federal and State environmental agencies, and analysis of required construction practices.

No evidence of HTRW has been identified in the reconnaissance-level study of the project construction sites. However, technical review and coordination will be continued to remain aware of the results of feasibility-level studies. This effort includes study team meeting attendance, provision of assistance and guidance to the study and technical team support, review of environmental and engineering design studies, and preparation of scope and study cost estimates for the PMP and planning, engineering, and design account of the detailed MCACES cost estimate for the NED plan.

10.16 Sedimentation Studies

This task will be performed by the Corps. This task includes detailed geomorphic studies (output must be compatible with Arc Info and Intergraph), sediment transport analysis, and preparation of a sedimentation report documenting the studies, analysis, and conclusions complete with charts, photographs, and test results. Results of the sedimentation studies will be used with other data to determine the uncertainties in the stage-discharge rating curves to be used in the risk base analysis. A risk and uncertainty analysis will also be included.

10.17 Real Estate Studies

Major Study Products. Real Estate Division study input will include preparation of preliminary real estate cost estimates for project right-of-way requirements, participation in Pre-local Cooperation Agreement activity, preparation of real estate supplement (RES) for inclusion in the feasibility report, preparation of a Gross Appraisal Report, preparation of baseline cost estimate for real estate prepared in the code of accounts format, and preparation of scopes of work outlining real estate input to the PMP.

Major Study Activities - Coordination. This activity includes, but is not limited to, Sacramento District Real Estate participation in team meetings, negotiation of work, coordination with other offices on project data needed for Real Estates five major study products, and monitoring of progress and findings associated with Real Estate study products.

Preparation of Preliminary Real Estate Cost Estimates and Access Agreements. This activity includes the development of preliminary (reconnaissance level of detail) cost estimate(s) of total real estate cost associated with proposed project scenario. The real estate cost estimate(s) will include a value estimate of the project's real property requirement, and

an estimate of any Public Law 91-646 relocation payments required as a result of the project's real property acquisitions, an estimate of the local sponsors' administrative cost to accomplish the project's real property requirements and an estimate of the Corps' administration cost to assist and monitor the local sponsors' real property acquisition program.

Preparation of Real Estate Supplement. This activity includes preparation of the RES which is an overall plan describing the minimum real estate requirements for the project (see ER 405-1-12, Draft Chapter 12).

Preparation of Gross Appraisal. This activity includes preparation of a Gross Appraisal Report which provides a detailed estimate of all real estate costs associated with acquisition of the project's real property requirements. (See ER 405-1-12, Draft Chapter 12, Section III, Appraisals, Paragraph 12-12b and Real Estate Policy Guidance Letter Number 3, Guidance for Preparation of Gross Appraisals.)

Preparation of Real Estate Mapping. Preparation of Real Estate preliminary owner plates and final plates and determine acreage.

Review and Revise Report Documents. This activity includes all Sacramento District Real Estate activity involved in reviewing the feasibility report and responding to South Pacific Division comment.

Preparation of Baseline Cost Estimate for Real Estate. This activity includes accounting for the project's total estimated real estate cost in code of accounts format as required by EC 1110-2-538 under Feature Codes 01, Lands and Damages. This estimate of total real estate cost should include estimated costs for all Federal and local sponsors' activities necessary for completion of the project.

Real Estate Input to the PMP. This activity includes ensuring that the RES is provided to the project manager and its components are properly incorporated into the PMP. Also includes Chief of Real Estate Division endorsement of the PMP which certifies that the real estate requirements, including schedule of acquisition, are adequately and accurately included in the PMP.

10.18 Study Management

This task will be conducted by the Corps and the non-Federal sponsor. Tasks common to the Corps and the non-Federal sponsors include preparation of correspondence, inter-organization coordination, and conference preparation and presentation. Periodic meetings will be held between the Corps and the non-Federal sponsors to coordinate and monitor in-kind services. Monthly status reports covering selected financial and performance measurements will be provided by the Corps. Study Management Team meetings will be scheduled monthly.

Corps tasks include managing all activities in accordance with current guidelines outlined in ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies, and ER 5-7-1, Project Management. Tasks include study scheduling; providing detailed information for the task to be conducted; issuing WOR's; establishing and monitoring study milestones; developing task activities, task schedules, critical path milestones, and funding schedules; and directing, monitoring, and modifying assigned task items and funds as required.

The Corps study manager will ensure that all required tasks are performed to produce a high-quality feasibility report. The study manager will maintain coordination with the multi-disciplinary study teams to ensure effective and timely decision making. The study manager will monitor the scope and progress of study activities to keep the study within budget and on schedule. The study manager will take necessary action to resolve potential scope, schedule, cost, and funding problems.

The non-Federal sponsors will perform study management tasks needed to complete work items during the feasibility study. The tasks include coordination of activities with the Corps on in-kind services and management of those activities. This includes managing study tasks, scheduling the study, and preparing the budget and funding status reports.

10.19 Plan Formulation

This tasks will be performed by the Corps and the non-Federal sponsor.

Plan formulation will be in accordance with ER 1105-2-100, Principles and Guidelines (P&G), NEPA, and other pertinent engineering, environmental, and economic guidance and regulations. Plan formulation includes reviewing and refining the plans selected for study during the feasibility phase and other plans developed during the course of study and developing required plans including the no action plan. This task includes identifying the NED plan, considering any environmental impacts and the views of the public, and formulating mitigation measures. Plan formulation will use risk and uncertainty analytical methodology. The costs and benefits associated with each plan will be determined, and tradeoffs required to select the recommended plan for implementation will be identified. Plan formulation includes application of engineering, economic, environmental, and other criteria to the specific problems, needs, and constraints of the study area to develop and analyze various methods, measures, and plans and their contributions and effectiveness in addressing the specific problems. It is an iterative process and requires constant review, reformulation, and public input.

Critical to the process of plan formulation will be the development of the without-project condition as a basis for comparison and evaluation of alternatives and the recommendation of any key project features and/or related mitigation requirements.

The annual and periodic activities and responsibilities for operating and maintaining the completed project will be described and closely coordinated with other requirements (e.g., cost estimates and environmental monitoring). The general magnitude of these activities will be described for all alternatives in detail; however, more detail will be provided for the alternative(s) recommended for implementation. All requirements of 33 CFR 208 and other Federal regulations specifying operation and maintenance requirements will be clearly described so that the non-Federal sponsors' future responsibilities will be known.

The Corps will perform plan formulation as it relates to overall formulation and screening of alternatives and all formulation tasks other than those noted for the non-Federal sponsor.

10.20 Report Preparation

This task will be performed by the Corps, with input from the non-Federal sponsor. The task will include collection and assembly of pertinent data, writing, editing, word processing, figures and plates, reviewing, revising, reproducing, and distributing the draft and final feasibility reports which include all technical appendixes. This task includes all support work necessary from the initiation of the feasibility study through the Assistant Secretary of the Army's Civil Works (ASA[CW]) request to the Office of Management and Budget (OMB) regarding the administration's views and policies.

10.21 Project Management

This task will be performed by the Corps. This task includes involvement by the Programs and Project Management Division, which is responsible for monitoring funds and schedules and managing the project programming. The Programs Management Section will be responsible for project budget development, schedules, defenses, execution of Congressional testimony, and preparing programmatic, multi-year budgets. The project manager will make presentations to higher authority justifying the budget and schedules and is responsible for preparing the PMP and required PES reports.

Specifically, the project manager will report monthly to the PRB and prepare the monthly PES report for CESPD. The PRB will review the Westside Tributaries PES for compliance with the IPMP and will provide comments to CESPD and the project manager. The sponsors will be afforded the opportunity to attend the PRB. In addition, support and overall guidance will be provided by the project manager to the technical manager through conversations and attendance at any Executive Committee meetings. The project manager will negotiate agreements with project partners and other agencies under established government policies. The project manager, with input from other District elements, will be responsible for developing the comprehensive project funding, schedule, and acquisition strategy as part of the PMP.

Also, the project manager will coordinate and process schedule and cost changes to the IPMP. This is done through the use of the SACCR form which can be initiated by any person working on the study who first recognizes a need for a change. Once initiated, the project manager is responsible for coordinating the SACCR change with the non-Federal sponsor, Study Management Team members, PRB, and higher authority.

Other project manager duties include preparing and presenting the future year budgets at the Corps May budget conference, preparing the current year's budget for the winter budget briefing, and issuing primary work orders. This task includes funds for a program analyst to monitor and correct charges to the study and to prepare budget documents.

10.22 Review Support

This task will be performed by the Corps and the non-Federal sponsor. This task covers any requirements for additional rewriting, unforeseen technical modifications, reformulation, or documentation as a result of the Washington-level review process.

This task includes items necessary to support the review process from the issuance of the Division Engineer's Public Notice to the request by the ASA(CW) to the OMB for the views of the administration. These items could also include answering comments resulting from the Washington-level review and comments by the non-Federal sponsors, public, and other Federal agencies; attending meetings; and revising the report.

10.23 Fish And Wildlife Studies

This task will be performed by the Corps, in coordination with staff from other agencies. The task includes environmental studies performed by FWS in cooperation with the Corps as required by the Fish and Wildlife Coordination Act. The FWS will form an interagency team to conduct a Habitat Evaluation Procedure (HEP) and other similar studies to define impacts and determine the amount of required mitigation. In these studies, baseline conditions and project-induced environmental effects will be evaluated, and types and amounts of mitigation for habitat losses will be determined. This task also includes management of the FWS task agreement. An FWS CAR will be prepared that will refine environmental effects of the selected alternative, summarize the HEP and other study findings, and analyze mitigation strategies acceptable to the FWS.

10.24 Survey - Flood Plain (A/E)

This task will be performed by a contractor, who will do spot elevation surveys of about 25 square miles of the flood plain that is delineated on Plate 4 of the reconnaissance report. Topographic maps with a scale of 1"=500' and 5-foot contours will be used in the surveying. The contractor will prepare a report documenting the purpose, assumptions, methodology, and results of the work. The report will be complete with tables, charts, graphs, and maps.

10.25 Survey - Channel (A/E)

This task will be performed by a contractor, who will survey about 16 miles of channel from Road 94B to the end of the Cache Creek settling basin. The contractor will provide eight cross sections per mile for about 10 miles from I-5 to the settling basin. The cross sections will be 2,000 feet wide. Topographic maps with a scale of 1"=200' will be used in the surveying. The contractor will prepare a report documenting the purpose, assumptions, methodology, and results of the work. The report will be complete with tables, charts, graphs, and maps.

10.26 Foundation & Material (A/E)

This task will be performed by a contractor, who will drill at the proposed setback levee sites and existing levee sites. The drilling is to evaluate the foundation and stability of the levees. The contractor will prepare a report documenting the purpose, assumptions, methodology, and results of the work. The report will be complete with tables, charts, graphs, and maps.

10.27 Foundation & Material (CESPD Lab)

This task will be performed by the CESPD lab, which will analyze material particles to determine the strength of the material. The CESPD lab will prepare a report documenting the purpose, assumptions, methodology, and results of the work. The report will be complete with tables, charts, graphs, and maps.

11.0 FEASIBILITY STUDY COST ESTIMATE

The feasibility study cost estimate for the Westside Tributaries is $2.2 million. All feasibility phase study costs are required to be cost-shared between the Corps and the non-Federal sponsors on a 50-50 basis. Further, the non-Federal sponsors will provide, at a minimum, half of their share as a cash contribution. Table 1 outlines the tasks to be performed, the estimated cost of each task, and study obligations for the Corps and non-Federal sponsor. Supervision and administration is covered under each task cost as overhead.

The feasibility study cost estimate is based on October 1994 price levels, and inflation has been taken into account for the out years. Inflation adjustments will be administered to the appropriate tasks at the current year's approved rate. Changes in costs due to inflationary adjustments will not require a revision to the FCSA.

12.0 FEASIBILITY STUDY SCHEDULE

The final feasibility report, engineering appendix, and EIS/EIR are scheduled to be submitted to CESPD approximately 36 months after initiation of the feasibility study. The

signing of the FCSA is scheduled to take place 2 to 4 weeks prior to initiation of the study. The Division Engineer's issuance of the Public Notice ends the feasibility study and is scheduled 1 month after the final feasibility report is submitted. The feasibility phase is completed when the final feasibility report is submitted to the OMB.

13.0 COORDINATION BETWEEN THE CORPS AND THE NON-FEDERAL SPONSOR

The Executive Committee is scheduled to meet at the signing of the FCSA and periodically (i.e., public meetings, Issue Resolution Conference, and the Feasibility Review Conference) to discuss the project status and to handle changes in study scope that would result in an increase in total study cost or major changes in study direction. The Study Management Team will meet approximately every 4 to 8 weeks.

Financial coordination will include quarterly financial statements composed of expenditures and obligations. The Corps will also provide quarterly reports to the non-Federal sponsor, which will include "Selective F&A Data Base Record, Form 666." The non-Federal sponsors will provide to the Corps, on a quarterly basis, similar finance and accounting data that will record cash expenditures and task-in-kind efforts by the non-Federal sponsor. Cost-sharing cash payments will be made to the Corps in the beginning of each quarter of each year beginning the first year of the feasibility study and running through the end of the feasibility study. The first payment will be made upon initiation of the study for the amount expected to be expended during the time until the next scheduled payment as outlined above. A final audit of the cost-sharing agreement and reconciliation of cash payment will be made at the conclusion of the study. The Corps will also furnish to the non-Federal sponsors a monthly PES report.

TABLE 1
FEASIBILITY STUDY COST ESTIMATE FOR CACHE CREEK WESTSIDE TRIBUTARIES (YOLO COUNTY), CA

TASK	CORPS	SPONSORS CASH	SPONSORS IN-KIND	TOTAL
01 Public Involvement	$		$	$ 30,000
02 Institutional Studies				10,000
03 Social Studies				10,000
04 Cultural Resource Studies				20,000
05 Environmental Studies				100,000
06 Economic Studies				72,000
07 Surveying and Mapping - Flood Plain				10,000
08 Surveying and Mapping - Channel				10,000
09 Hydrology				25,000
10 Hydraulic Design				90,000
11 Flood Plains				45,000
12 Foundation & Materials				30,000
13 Design				85,000
14 Cost Estimates				20,000
15 Environmental Engineering				8,000
16 Sedimentation Studies				35,000
17 Real Estate Studies				40,000
18 Study Management				100,000
19 Plan Formulation				50,000
20 Report Preparation				50,000
21 Project Management				40,000
Sub-Total	$			$ 880,000
Contingency				132,000
Indirect & Overhead				792,000
Sub-Total	$			$1,804,000
22 Review Support				50,000
23 Fish & Wildlife Studies				100,000
24 Survey-Flood Plains (A/E)				30,000
25 Survey-Channel (A/E)				150,000
26 Foundation & Material (A/E)				30,000
27 Foundation & Material (SPD Lab)				36,000
TOTAL	$1,100,000	$ 550,000	$ 550,000	$2,200,000

The maximum study costs can be up to 15% greater than the total shown in Table I per Article III of the FCSA.

WESTSIDE TRIBUTARIES (YOLO COUNTY), CALIFORNIA

WORK BREAKDOWN STRUCTURE

Public Involvement

- Conduct public meetings and workshops
- Prepare mailing list for information notices

Institutional Studies

- Perform financial analysis
- Prepare financing plan
- Coordination with sponsor
- Provide input for PMP

Social Studies

- Conduct social environment studies
- Determine impacts of alternatives
- Provide input for PMP

Cultural Resources

- Perform cultural field survey
- Perform evaluation for National Register
- Prepare cultural resources report
- Provide input for PMP

Environmental

- Prepare environmental impact statement (EIS/EIR) report
  - Conduct baseline studies
  - Determine environmental impacts of alternatives
  - Develop mitigation requirements
  - Coordinate with USFWS for biological assessment
  - Coordinate with USFWS preparation of the coordination act report (CAR)
  - Conduct HEP analysis
  - Prepare draft EIS/EIR
  - Submit draft for public review
  - Respond to comments
  - Write final EIS/EIR
- Provide input for PMP

Economic Studies

- Inventory of existing structures and other damageable properties in the flood plain (First floor elevations and property values determined)
- Set uncertainty parameters for economic data
- Derive stage-damage relationships (Incorporate WSEL)

Perform risk and uncertainty analysis incorporating hydrologic and hydraulic data (At risk program)
Evaluate future growth and hydrology
Determine inundation reduction benefits for each alternative
Consider other flood control benefit categories
Write economic appendix
Provide input for PMP

Surveys & Mapping

Review existing surveys and maps of study area
Develop topographic maps of study area
Develop streambed cross sections
Develop supplemental cross sections at bridge crossings
Transfer data in electronic or hardware format

Hydrology

Review existing literature and hydrology data
Verify rainfall-runoff criteria
Perform interior drainage analysis for selected plan
Perform risk based analysis
Provide input for PMP

Hydraulic Design

Review of existing data
Conduct field investigations
Perform sedimentation and sediment routing studies
Perform induced flooding analysis
Perform interior flood control analysis
Perform risk based analysis
Prepare hydraulic design office report
Provide input for PMP

Flood Plains

Develop flood plains using present and future condition overflows
Develop flood plain maps
Prepare flood plain report

Foundation & Materials

Perform literature search
Conduct field investigations
Conduct explorations and soil sampling
Conduct lab testing
Perform risk based analysis

Prepare geotechnical office report
Provide input for PMP

Design

Prepare basis of design
Develop feasibility level design and quantities for alternatives, NED plan
Develop O & M requirements
Assess HTRW for each alternative
Write basis of design report
Provide input for PMP
Perform detail design analysis of concrete line section for bridge crossing
Prepare write up of engineering design
Provide input for PMP

Cost Engineering

Develop baseline cost estimates for the alternatives, NED
Prepare MCACES cost estimate for NED plan
Perform sensitivity analysis
Prepare narrative basis of estimate report
Provide input for PMP

Environmental Engineering

Field reconnaissance of the study area
Literature review
Coordination with EPA and other Federal, State, and local agencies
Prepare documentation of findings

Sedimentation Studies

Perform geomorphic analysis
Determine quantity and distribution of sediment for design and cost estimates for alternatives and NED
Prepare sedimentation office report
Perform risk based analysis
Provide input for PMP

Real Estate

Obtain rights-of-entry for geotechnical, environmental, surveying and engineering studies
Prepare preliminary real estate cost estimates
Participate in Pre-Local Cooperation Agreement
Prepare Real Estate Supplement
Prepare Gross Appraisal Report

Prepare baseline cost estimate for real estate prepared in the Code of Accounts format
Provide input for PMP

Study Management

Manage budget and schedule activity
Coordinate technical study elements
Prepare feasibility document of study findings
Prepare and issue work under requests to technical elements

Plan Formulation

Scope feasibility study
Prepare and issue work order requests
Manage technical studies
Formulate alternatives
Evaluate benefits/costs for each alternative
Identify NED plan and LPP
Provide input for PMP

Report Preparation

Prepare pre-conference materials for milestones F3, F4, and F5
Prepare draft feasibility report
Submit draft report for review
Respond to comments
Write final feasibility report

Project Management

Monitor study funds and schedules
Management of the project programming process
Prepare PMP

WESTSIDE TRIBUTARIES (YOLO COUNTY), CALIFORNIA

STUDY SCHEDULE

Milestone	Description	Date	Month
F1	Start Feasibility	Oct 94	1(st)
F2	Public Workshop	Dec 94	3
F3	Conference #1	Aug 95	11
F4	Conference #2	Feb 96	17
F5	Draft Feasibility Report to SPD	Sep 96	24
F5A	Feasibility Review Conference	Nov 96	26
F6	Field Level Coordination	Dec 96	27
F7	Final Public Meeting	Feb 97	29
F8	Dist. Eng Submit Feas Rpt to SPD	Aug 97	35
F9	Div Engineer Public Notice	Sep 97	36

WESTSIDE TRIBUTARIES (YOLO COUNTY), CALIFORNIA

ORGANIZATIONAL BREAKDOWN STRUCTURE

The Organizational Breakdown Structure (OBS) identifies all of the elements that contribute to completing this study. District elements and office symbols are listed below.

CESPK-DE	District Engineer
DD-P	Deputy District Engineer (Project Management)
PD	Planning Division
PD-E	Economics Branch
PD-F	Flood Plain Mgmt Branch
PD-S	Sacramento Basin Branch
PD-R	Environmental Resources Branch
PD-R	Environmental Planning Section
PD-R	Environmental Analysis Section
PD-R	Public Involvement & Reports Control Section
ED	Engineering Division
ED-D	Civil Design Branch
ED-D	Civil Projects Section A
ED-D	Hydrology Section
ED-D	Hydraulic Design Section
ED-D	Structural Design (CW) Section
ED-E	Environmental Engineering Branch
ED-E	Environmental Engineering Section A
ED-G	Geotechnical Branch
ED-G	Soil Design Section
ED-G	Survey Section
ED-G	Geology Section
ED-C	Cost Engineering Branch
OC	Office of Counsel
PPMD	Programs & Project Management Division
PM-C	Civil Works Branch
PM-C	Sacramento Basin/East Area Unit
RE	Real Estate Division
RE-C	Acquisition Branch
RE-A	Appraisal Branch
RE-P	Planning and Control Branch

CESPD	South Pacific Division
WLRC	Washington Level Review Center
HQUSACE	Headquarters, U.S. Army Corps of Engineers
ASA(CW)	Assistant Secretary of the Army, Civil Works
USFWS	U.S. Fish and Wildlife Service
DWR	Department of Water Resources (State)

WESTSIDE TRIBUTARIES (YOLO COUNTY), CALIFORNIA

RESPONSIBILITY ASSIGNMENT MATRIX

TASKS	RESOURCES
Public Involvement	PD-R
Conduct public meetings and workshops	
Prepare mailing list for information notices	
Institutional Studies	PD-B
Perform financial analysis	
Write draft report	
Review draft report	
Finalize financing plan	
Coordination with sponsor	
Provide input for PMP	
Social Studies	PD-R
Conduct social environment studies	
Determine impacts of alternatives	
Provide input for PMP	
Cultural Resources	PD-R
Perform cultural field survey	
Perform evaluation for National Register	
Prepare Cultural Resources Report	
Provide input for PMP	
Environmental	PD-R
Prepare environmental impact statement (EIS/EIR) rpt	
Conduct baseline studies	
Determine environmental impacts of alternatives	
Develop mitigation requirements	
Coordinate with USFWS for Biological Assessment	
Coordinate with USFWS preparation of the Coordination Act Report (CAR)	
Conduct HEP analysis	
Prepare draft EIS/EIR	
Submit draft for public review	
Respond to comments	
Write final EIS/EIR	
Provide input for PMP	

Economic Studies PD-E

Inventory of existing structures and other damageable properties in the flood plain (First floor elevations and property values determined)
Set uncertainty parameters for economic data
Derive stage-damage relationships (Incorporate WSEL)
Perform risk and uncertainty analysis incorporating hydrologic and hydraulic data (At risk program)
Evaluate future growth and hydrology
Determine inundation reduction benefits for each alternative
Consider other flood control benefit categories
Write economic appendix
Provide input for PMP

Surveys & Mapping ED-G

Review existing surveys and maps of study area
Develop topographic maps of study area
Develop streambed cross sections
Develop supplemental cross sections at bridge crossings
Transfer data in electronic or hardware format

Hydrology ED-D

Review existing literature and hydrology data
Verify rainfall-runoff criteria
Determine without-project discharge-frequency values
Develop inflow hydrographs for detention basin sizing
Perform interior drainage analysis for selected plan
Perform risk based analysis
Provide input for PMP

Hydraulic Design ED-A

Review of existing data
Conduct field investigations
Conduct detention basin design volume analysis
Provide elevation-storage rating curves
Perform sedimentation and sediment routing studies
Perform induced flooding analysis
Perform interior flood control analysis
Perform risk based analysis
Prepare hydraulic design office report
Provide input for PMP

Flood Plains PD-F

Develop flood plains using present and future condition overflows
Develop flood plain maps
Prepare flood plain report

Foundation & Materials ED-G

Perform literature search
Conduct field investigations
Conduct explorations and soil sampling
Conduct lab testing
Perform risk based analysis
Prepare geotechnical office report
Provide input for PMP

Design ED-D

Prepare Basis of Design
- Develop feasibility level design for NED alternative
- Develop quantities for selected plan
- Assess HTRW for each alternative
- Write basis of design report

Provide input for PMP

Cost Engineering ED-C

Develop baseline cost estimates for the alternatives, NED
Prepare MCACES cost estimate for NED plan
Perform sensitivity analysis
Prepare narrative basis of estimate report
Provide input for PMP

Real Estate RE

Prepare preliminary real estate cost estimates
Participate in Pre-Local Cooperation Agreement
Prepare Real Estate Supplement
Prepare Gross Appraisal Report
Prepare baseline cost estimate for Real Estate prepared in the Code of Accounts format
Provide input for PMP

Study Management PD-B

Manage budget and schedule activity

Plan Formulation PD-B

Scope feasibility study
Prepare and issue work order requests
Manage technical studies
Formulate alternatives
Evaluate benefits/costs for each alternative
Identify NED plan
Provide input for PMP

Report Preparation PD-B

Prepare pre-conference materials for milestones F3, F4, and F5
Prepare draft feasibility report
Submit draft report for review
Respond to comments
Write final feasibility report

Sedimentation Studies ED-A

Coordination with Committee for Channel Stabilization
Perform geomorphic analysis
Determine quantity and distribution of sediment for design and cost estimates for alternatives and NED
Perform risk based analysis
Prepare sedimentation office report
Provide input for PMP

Project Management PM

Monitor study funds and schedules
Management of the project programming process
Prepare PMP